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Comparability and validity of cancer registry data in the Northwest of Russia

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Abstract

Background

Despite the elaborate history of statistical reporting in the USSR, Russia established population-based cancer registries (PBCR) only in the 1990s. The quality of PBCRs data has not been thoroughly analyzed. This study aims at assessing the comparability and validity of cancer statistics in regions of the Northwestern Federal District (NWFD) of Russia.

Material and Methods

Data from ten Russian regional PBCRs covering approximately 13 million (~ 5 million in St. Petersburg) were processed in line with IARC/IACR and ENCR recommendations. We extracted and analyzed all registered cases but focused on cases diagnosed between 2008-2017. For comparability and validity assessment, we applied established qualitative and quantitative methods.

Results

Data collection in NWFD is in line with international standards. Distributions of diagnosis dates revealed higher variation in several regions, but overall, distributions are relatively uniform. The proportion of multiple primaries between 2008 and 2017 ranged from 6.7% in Vologda Oblast to 12.4% in Saint-Petersburg. We observed substantial regional heterogeneity for most indicators of validity. In 2013-2017, proportions of morphologically verified cases ranged between 61.7% and 89%. Death certificates only (DCO) cases proportion was in the range of 1-14% for all regions, except for Saint-Petersburg (up to 23%). The proportion of cases with a primary site unknown was between 1% and 3%. Certain cancer types (e.g., pancreas, liver, hematological malignancies, and CNS tumors) and cancers in older age groups showed lower validity.

Conclusion

While the overall level of comparability and validity of PBCRs data of four out of ten regions of NWFD of Russia meets the international standards, differences between the regions are substantial.
The local instructions for cancer registration need to be updated and implemented. The data validity assessment also reflects pitfalls in the quality of diagnosis of certain cancer types and patient groups.

Keywords: cancer registry; data quality; comparability; validity; Russia, Northwest of Russia.

Background

In Russia, the national cancer surveillance system relies on a network of regional population-based cancer registries (PBCRs) that register all in situ and malignant neoplasms [1]. Despite the long history of statistical reports in the Soviet Union, automated individual-level data collection by PBCRs did not start until the early 1990s. Russia introduced definitions for Regional and National Cancer Registries in 1996, and the most recent international description of cancer registration in Russia was given in 1998 [2,3]. At least two former USSR countries (Estonia and Ukraine) have published reports on the quality of cancer registration since 1998 [4,5]. Despite substantial advances through national legislative acts introduced in 1996 and 1999, information on cancer registration practices and data quality in the Russian Federation has not been systematically compiled and published until only recently [6].

For cancer registration procedures and practices to be nationally and internationally comparable, PBCRs should follow well-defined international recommendations and standards, but in reality, they vary [7]. The quality of data from PBCRs is traditionally assessed with reference to four standard dimensions: comparability, validity, completeness, and timeliness [8,9]. Qualitative, semi-quantitative, and quantitative methods can be applied to individual-level databases to assess quality indicators and gauge data quality.

Our report focuses on data from PBCRs in the Northwestern Federal District (NWFD) of Russia, which encompasses eleven regions with a population of around 13 million (approximately 9.5% of the country's total population). The Ministry of Healthcare tasked three national cancer centers to implement and monitor cancer control policies across the country in 2018. The National Research Medical Center of Oncology, named after N. N. Petrov (NRMCO), located in Saint-Petersburg, was responsible for assessing and improving the cancer surveillance system in the NWFD. The present report focuses on the data comparability and validity of PBCRs in the region.

Material and Methods

Instructions for cancer registration and classifications are provided in The Order by the Ministry of Health of Russia #135 issued in 1999 [1]. In Russia, the cancer registration system can be formally described as passive and exhaustive, with paper-based notification forms used to report cases. PBCRs collect personal information, tumor characteristics, information about the treatment type, and follow-up data. All data are stored in the electronic databases of regional PBCRs, usually part of regional cancer hospitals – "dispensaries". PBCRs regularly perform linkage with the death certificates available in regional civil registries.

According to Order #135, PBCRs use adapted ICD-10 (similar to 5-digit ICD-10-CM (Clinical Modification) to code topography, ICD-O-2 for morphology, and the 5th AJCC/UICC TNM classification for staging. The exact version TNM of classification is not available from the registry database. Detailed description of history and current status of cancer registration is available in a recently published report [6].

In our analyses, we use data from ten PBCRs databases of eleven regions of the NWFD (the Arkhangelsk Oblast (including the Nenets Autonomous Okrug), the Murmansk Oblast, the Republic of Komi, the Republic of Karelia, the Pskov Oblast, the Kaliningrad Oblast, the Leningrad Oblast, the Novgorod Oblast, the Vologda Oblast, Saint-Petersburg) extracted in December 2019 (Figure 1).

Data

We extracted data for all cases of malignant neoplasms (C00-C96 codes in ICD-10) and selected variables according to the essential variables list recommendations for PBCRs [7]. We performed the multistep conversion and cleaning procedure using "IARC/IACR Tools for Cancer Registries" software (IARC tools). We assigned ICD-O-3 codes to all registered cases and applied IARC/IACR/ENCR multiple primary rules to delete duplicates [10]. Data processing is summarized in Figure 2. Cases diagnosed between 2008-2017 were selected for primary analysis (569,445 cases).

Age-standardized rates (ASRs) per 100,000 (Segi-Doll world standard [11]) were calculated for cancer incidence and mortality using mid-year population estimates by region, cause, sex, and five-year age groups from the Russian Fertility and Mortality Database (the RFMD) [12].

In tables similar to IARC "Cancer Incidence in Five Continents" (CI5) volumes, we summarized the number of cases, deaths, rates, and the basic quality indicators: the proportion of morphologically verified cases (MV%), the proportion of cases registered with information available from death certificates only (DCO%), and the mortality to incidence ratio (M:I). We compared estimates with 12 East European cancer registries from CI5 volume X (2003-2007): (Bulgaria, Croatia, Czech Republic, Latvia, Lithuania, Poland (Cracow), Poland (Lower Silesia), Poland (Kielce), Poland (Podkarpackie), Slovakia, Slovenia, Serbia) using recommended statistical tests. An overdispersion parameter, corresponding to excess variation between registries, is added to models - Poisson for rates and binomial for DCO% and MV% The regional dynamics is assumed to be homogeneous. Then rates and proportions were flagged as unusual based on test statistics if rates were greater than three times or less than 0.3 times of the value in the comparison population [13]. Detailed tables for individual regions are provided in *Supplementary Material*.

We produced plots to preliminary assess overall cancer (C00-C96) incidence ASRs per 100,000 per calendar-year (Figure S1*).* Additional plots were produced for incidence ASRs of hematological malignancies (Figure S2). The rates in the Leningrad Oblast dropped dramatically in 2012-2014, suggesting problems with acquiring a complete data from that period. Mortality to incidence ratios are also suggesting the lack of completeness in Leningrad oblast. The Republic of Komi is the only region with data available from 1991, while Vologda Oblast started cancer registration only around 2005-2006. PBCR in Vologda Oblast has also begun data collection for hematological malignancies later (in 2012) than for solid tumors (in 2006).

Comparability

We evaluated the definitions used for incidence dates, handling multiple primary tumors, and incidental diagnosis (screening and autopsy diagnosis) [8]. We analyzed the distribution of incidence dates, temporal changes in stage-specific ASRs and reported autopsy proportions along with DCO percentage to explore patterns in the incidental diagnoses. We adjusted autopsy and DCO proportions among patients who died using logistic models with age, region, cancer type, and period as covariates.

Validity

To assess validity, we applied diagnostic criteria methods, missing information, and internal consistency checks. Along with MV% and DCO%, we reported the proportions of missing or uncertain information for different variables in the database. We also reported cases with primary site unknown (PSU%) - unknown primary site (C80), malignant neoplasms of ill-defined organs of the digestive system (C26), malignant neoplasms of ill-defined organs of the respiratory system (C39), peritoneal and retroperitoneal neoplasms (C48) and Other and ill-defined sites (C76). We assessed the proportions of cases with stage unknown (SU%), missing TNM coding, and non-specific morphology codes [10]. We used regression analysis using logistic models to obtain the adjusted effects of covariates (age, gender, region, and period) on the reported data quality indicators. We also assessed ASRs for major cancer types based on initial ICD-10 coding and reverse conversion based on ICD-O-3 coding performed with IARC tools software to detect any systematic deviations [10].

For our report, we aggregated all cancer sites in groups to match national mortality statistics (Table S1).

Results

Comparability

Only one date of diagnosis for each cancer case was available from the registry database. Distribution of diagnosis dates across the year revealed higher variation in several regions (Figure S3). Peaks and uneven distribution in Arkhangelsk oblast, Republic of Komi, Vologda oblast and Leningrad Oblast are observed, but overall, distributions are relatively uniform.

The proportion of multiple primaries between 2008 and 2017 ranged from 6.7% in Vologda Oblast to 12.4% in Saint-Petersburg (Figure 2). After applying IARC/IACR/ENCR multiple primaries rules, we found only minor systematic over-reporting of breast cancer incidence in most regions (Figure S4).

Breast cancer incidence ASRs demonstrated a consistent increase in all the regions of the NWFD, primarily due to a rise in localized stage lesions (Figure 3). A similar but more extreme increase in localized stage thyroid cancer rates was evident (Figure S5). The recent increase in prostate cancer rates in most regions appeared attributable to both localized and advanced-stage tumors (Figure S6).

The proportion of deaths with reported autopsies varied between the regions and periods from less than 10% in Kaliningrad and Novgorod oblast to more than 60% in Arkhangelsk oblast in 2017. Autopsy status predicted DCO diagnosis among deceased patients regardless of cancer type, region, age, and period (Figure S7).

Validity

The proportions of MV and DCO cases along with incidence and mortality ASRs and M:I ratios are summarized in Table 1 and by cancer type in Tables S2-S21. DCO% was in the range of 1-14% for all regions, except for Saint-Petersburg where DCO% high in both men and women in both periods and for all cancer types. Liver, CNS, and pancreas cancer cases were most frequently registered based on death certificates only. As a result of high DCO%, Saint-Petersburg exhibited the lowest MV%. MV% was also relatively low in Novgorod Oblast and Leningrad Oblast. Pskov and Vologda oblast PBCRs registered an unusually high proportion of cases with cytological confirmation of diagnosis (43% and 35%, respectively) (Figure S8). Proportions of cases with the cytological diagnosis were below 15% in all other regions and were common only for skin cancer and leukemia. Hematological malignancies, pancreas, lung, liver, and CNS tumors were commonly registered without morphological verification in all the regions of NWFD. Additionally, older age (particularly 60+) was an independent predictive factor for DCO and the absence of MV (Figure S9).

The proportion of cases with a PSU was between 1% and 3%. Age was the independent factor for a higher proportion of cases with the PSU. The relationship was not linear with higher adjusted proportions in very young (0-4 age group – 8.1%) and older age groups (85+ age group – 4.3%). (Figure S10).

The proportions of cases with missing and non-specific morphology codes decreased over the analyzed period but remain high in some regions (e.g., Saint-Petersburg, Leningrad, and Kaliningrad oblast). In Novgorod Oblast, most of the cases registered in 2016 and 2017 still had missing morphology codes. In Vologda oblast, the proportion of cases with non-specific morphology was around 20%. Missing morphological codes were common in the following cancer groups: liver (58%), pancreas (56%), CNS (41%), lung (36%), non-specific codes were most common in other and ill-defined tumors (28%), Non-Hodgkin's lymphoma (28%), leukemia (14%) and lung (11%) (Figure S11).

The lowest proportion of cases with information on tumor stage was in Leningrad Oblast (less than 60%). The proportion of cases with missing information on stage varies by cancer type (Figure 4). N stage category information was more often missing than T or M stage in most cancer types in all regions of the NWFD. Age younger than 20 or older than 60 was associated with a higher proportion of missing values. (Figure S12).

The number of cases reported for different primary sites (ICD-10 groups) in the original databases was similar to those reported after the conversion and cleaning. The proportion of misclassified primary sites overall was 0.6% - it was highest in the Republic of Komi in 2008-2012, at 1.6%, and lowest in Saint-Petersburg in the same period, at 0.2%. The IARC tools revealed 31,196 warnings for 29,583 individual records of the total of 590,290 cases (5.2%) registered in 2008-2017. The majority of the warnings were related to grade/histology, the basis of diagnosis/histology, and histology/site combinations (12,749; 13,294; and 4,180 warnings, respectively) with the highest rates for hematological malignancies.

Discussion

This study is the first comprehensive quantitative assessment of the comparability and validity of ten PBCRs from the Russian Federation. Thus, it represents the largest and most systematic assessment of the quality of cancer registration in Russia. We observed notable heterogeneity for most quality indicators by region, cancer site, and age. Older age and hematological malignancies were associated with lower data validity. We also observed the effects of diagnostic and screening activities on cancer incidence (mainly skin, breast, and thyroid), which should be considered when comparing cancer burdens in different populations. Our findings are in line with previous quality assessments of other Eastern European PBCRs [5,14].

Comparability

The findings highlight the differences between national and international recommendations that can lead to apparent problems with comparability. Even though PBCRs in Russia use a combination of modified ICD-10 and ICD-O-2 morphology, the apparent differences from ASRs reported using ICD-O-3 were seen only in liver cancer and some rare cancers (mesothelioma, thymus, endocrine cancers). This issue was most apparent for sites, where metastases are common, and diagnosis is challenging (e.g., liver, pancreas, lung, endocrine tumors, and mesothelioma) [15].

The analysis of diagnosis dates revealed certain dates assigned more frequently than expected, which may reflect a practice of entering a standard date for cases where the date or month is missing. We revealed quite reasonable proportions of multiple primaries (from 6.7% to 12.4%). These findings were similar to other cancer registries [16-18].

Analysis of stage-specific incidence ASRs of breast, cervical, prostate, and thyroid cancer indicates that changes in diagnostic practice and early detection programs may significantly affect the trends in the regions, making a comparison across years difficult [19,20]. Russia started nation-wide opportunistic screening in 2012, and regional healthcare officials were responsible for implementing this program. The range of free diagnostic procedures offered to target age groups included but was not limited to mammography, PSA, fecal occult blood test, cervical cytology. Besides that, thyroid exams and ultrasound became available and easily accessible to a healthy population.

Autopsy practices appear to be different across the regions, which may have an impact on comparability. An autopsy followed more than 60% of deaths in the Arkhangelsk Oblast PBCR. However, this proportion was not more than 30% in Novgorod Oblast, which is still materially higher than in most other parts of Europe [21]. The proportion of DCO cases increased with the number of autopsies in the Republic of Karelia, suggesting that at least some DCO diagnoses could be latent cases revealed only at autopsy. Autopsy proportions did not vary greatly across different cancer types, but DCO diagnoses were more common among cases with an autopsy. Audits are needed to explore further and explain the role of autopsy practices [22].

Validity

The proportions of DCO cases in Saint-Petersburg and Leningrad Oblast were larger than expected for high-quality cancer registration. The reasons are not clear and require further analysis. MV and DCO proportions in other regional PBCRs were similar to the corresponding estimates for Eastern European countries in the CI5-X [23]. However, MV proportions are usually higher in high-quality Western European PBCRs. [14].

Age at diagnosis was a significant independent predictor of the quality of cancer registration. The quality of cancer registration is partially linked to the quality of cancer diagnosis and cancer care. A study based on Dutch cancer registry data showed that cancer registries are more likely to miss older patients' information [24]. Although we did not include completeness assessment in this report, higher DCO proportions in older age groups may indicate a lack of completeness. Still, misclassification of diagnosis and stage might become an issue as well. This finding is also essential for cancer control programs in the light of population aging and the growing number of older patients.

PSU proportions were below 3%, which is comparable to some Southern and Eastern European countries [14]. Our analysis suggests a quite encouraging decline in the proportion of cases with missing morphological code in the most recent period. The lowest proportions of missing and non-specific codes were in the Murmansk Oblast and the Republic of Komi. The proportion of hematological malignancies with missing morphological codes is surprisingly high in the registries of NWFD, especially for Leukemia and Non-Hodgkin's lymphoma. This pattern reflects the lack of communication between PBCRs and facilities responsible for managing hematological malignancy outside regional cancer networks.

PBCRs collect information on the clinical stage providing greater research opportunities, but this data quality is also crucial. Overall, the N stage category was more likely to be missing than T and M category. This pattern may reflect not only registration but also diagnostic issues. Soft tissue, bone, and cartilage tumors represent the greatest challenge for diagnosis and staging; similar findings on stage completeness were observed in the Mallorca cancer registry [25].
The IARC check analysis showed that training in coding needs a particular focus on hematological malignancies that are being treated outside the oncology centers.

Limitations

This PBCRs data quality assessment focused on the comparability and validity of the data. The analysis of completeness and timeliness should supplement it. The validity of PBCR data needs to be further analyzed using re-abstracting and recoding audits, as some issues in cancer registration cannot be detected in the database analysis. Quality of staging information also requires an additional in-depth quality audit.

AJCC/UICC staging system may not be relevant for certain cancer types (especially hematological malignancies and cancers in children).

Arkhangelsk Oblast and the Republic of Karelia PBCRs are included in the latest CI5 Volume XI [26]. According to our analysis, at least two more PBCRs (Murmansk Oblast and the Republic of Komi) have data quality meriting inclusion in CI5 at the moment, and other regions can be considered future candidates. A similar analysis of PBCRs across all the regions could help identify more registries with reasonable data quality.

Conclusions

While the overall level of comparability and validity of PBCRs data in some but not all regions of NWFD of Russia fulfills the IARC/ENCR standards, differences between the regions of the NWFD of Russia are substantial. Probably, cancer registry data of a quality sufficient for surveillance and cancer research are also available for other Russian regions. However, the local instructions for cancer registration need to be updated and implemented in line with international standards, and a similar quality assessment process should be started for each PBCR in the whole of Russia. After completion of data quality analyses and implementation of any recommendations that may arise in updated guidelines and registration practices, PBCRs could then be more reliably used to guide and monitor cancer control activities. The validity of data from PBCRs may also reflect pitfalls in the quality of diagnosis and treatment, which appears most evident for certain cancer types (e.g., hematological malignancies and CNS tumors) and older patients.

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Conflict of interest statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper. Where authors are identified as personnel of the International Agency for Research on

Cancer / World Health Organization, the authors alone are responsible for the views expressed in this article, and they do not necessarily represent the decisions, policy or views of the International Agency for Research on Cancer / World Health Organization.

Authors' contributions

ABa conceived and designed the study; ABa, RT, ABe, and YK acquired the data; ABa, RT and JN analyzed the data; ABa, AAn, AAu, NM, AR and AZ drafted the manuscript; all authors critically reviewed, edited and approved the manuscript.

Ethical review

This research is a part of a collaborative effort of the NRMCO in Saint-Petersburg, Russia, Tampere University, Tampere, Finland, and the International Agency for Research on Cancer, Lyon, France. All data analysis was performed in NN Petrov National Research Medical Center of Oncology. In Russia ethical review is not required for registry-based research. According to the Russian national regulation (The Order of the Ministry of Health #420 12/23/96), anonymized cancer registry data from the NWFD are collected and maintained in NRMCO for various purposes, including epidemiological analyses and international cooperation.

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Table 1. Comparison of incidence and mortality rates (ASRs), the proportion of morphological verification (MV%), proportion of cases registered with information from death certificates only (DCO%), and mortality to incidence (M:I) ratios, regions of the NWFD of Russia, 2008-2012 and 2013-2017, all sites except for non-melanoma skin cancer (C00-96 excl. C44)

Women																		
	2008-2012									2013-2017								
	Incidence			Mortality			Quality indicators			Incidence			Mortality			Quality indicators		
Region	Cases	ASR (W)	SE	Deaths	ASR (W)	SE	MV (%)	DCO (%)	M:I ratio	Cases	ASR (W)	SE	Deaths	ASR (W)	SE	MV (%)	DCO (%)	M:I ratio
Arkhangelsk oblast	11 421	200.3	2.1	6 057	93.9	1.4	83.9	7.5	0.53	13 304	231.9	2.2	6 326	91.8	1.3	89.0	7.0	0.48
Kaliningrad oblast	8 103	190.6	2.3	4 524	94.6	1.6	71.4	1.0	0.55	9 241	202.1	2.3	4 803	92.6	1.5	82.2	1.8	0.52
Leningrad oblast	12 947	159.7	1.6	9 103	90.6	1.1	**66.6***	4.1	0.70	12 875	**148.3***	1.5	10 044	88.2	1.0	77.5	6.6	0.78
Murmansk oblast	7 487	224.1	2.8	3 320	94.4	1.7	90.2	1.5	0.44	8 362	245.7	2.9	3 459	92.5	1.7	92.1	4.4	0.41
Novgorod oblast	7 034	223.0	3.1	3 259	87.4	1.8	84.8	4.8	0.46	7 424	229.8	3.1	3 063	77.9	1.6	**61.7***	5.9	0.41
Pskov oblast	6 709	210.4	2.0	3 794	91.8	1.7	79.4	2.5	0.57	7 415	217.5	2.9	3 671	88.1	1.7	85.2	5.7	0.50
Republic of Karelia	7 102	242.9	3.2	3 431	96.4	1.8	77.9	1.5	0.48	7 550	247.6	3.2	3 533	93.9	1.8	85.5	3.5	0.47
Republic of Komi	7 710	216.2	2.6	3 704	95.5	1.7	76.7	1.5	0.48	9 681	263.4	2.9	3 956	95.4	1.6	81.4	6.0	0.41
Saint-Petersburg	59 082	219.5	1.0	34 146	108.5	0.7	**66.0***	**20.5 †**	0.58	69 873	247.1	1.1	35 816	105.5	0.7	**71.9***	**14.7†**	0.51
Vologda oblast	9 512	173.4	2.0	5 778	86.5	1.3	75.6	4.6	0.61	11 436	207.9	2.2	5 659	84.6	1.3	80.8	9.1	0.50
Men																		
	Incidence			Mortality			Quality indicators			Incidence			Mortality			Quality indicators		
Region	Cases	ASR (W)	SE	Deaths	ASR (W)	SE	MV (%)	DCO (%)	M:I ratio	Cases	ASR (W)	SE	Deaths	ASR (W)	SE	MV (%)	DCO (%)	M:I ratio
Arkhangelsk oblast	10 684	299.7	3.1	7 059	198.3	2.5	80.7	8.8	0.66	11 839	314.7	3.0	7 389	194.9	2.34	86.8	8.4	0.62
Kaliningrad oblast	6 570	237.1	3.1	4 778	171.0	2.6	66.2	1.9	0.73	7 357	239.2	2.9	5 126	165.5	2.37	77.1	2.4	0.70
Leningrad oblast	9 863	177.7	1.9	9 970	177.2	1.9	57.2	6.5	1.01	8 813	**143.0 ***	1.6	10 708	169.5	1.70	68.6	9.6	1.22
Murmansk oblast	6 023	315.5	4.5	3 481	182.3	3.4	86.6	2.4	0.58	7 045	349.5	4.4	3 638	180.6	3.20	90.2	7	0.52
Novgorod oblast	5 833	283.9	3.9	3 911	188.7	3.2	78.1	7.3	0.67	6 276	297.3	3.9	3 589	167.8	2.90	56.4	8.2	0.57
Pskov oblast	5 743	252.2	3.5	4 646	200.5	3.1	66.7	4.0	0.81	6 423	279.2	3.6	4 411	188.3	2.94	79.8	8.4	0.69
Republic of Karelia	5 664	300.6	4.2	4 054	214.3	3.6	65.1	2.9	0.72	6 087	304.8	4.1	4 065	202.0	3.29	78.4	5.2	0.67
Republic of Komi	6 426	285.7	3.9	4 522	207.6	3.4	68.4	2.1	0.70	8 154	345.7	4.1	4 896	212.5	3.24	73.8	8.8	0.60
Saint-Petersburg	42 848	270.6	1.4	28 913	179.8	1.1	**61.9***	**23.1†**	0.68	49 832	285.4	1.3	30 170	167.6	1.01	**67.1***	**17.2†**	0.61
Vologda oblast	8 376	227.7	2.6	7 180	193.9	2.4	72.3	6.3	0.86	9 810	258.2	2.7	7 076	183.7	2.27	73.2	13.8	0.72

Lower (*) or higher (†) results are marked in bold when compared with that from 12 cancer registries in CI5X 2003-2007: Bulgaria, Croatia, Czech Republic, Latvia, Lithuania, Poland (Cracow), Poland (Lower Silesia), Poland (Kielce), Poland (Podkarpackie), Slovakia, Slovenia, Serbia. All statistical tests are described in Cancer Incidence in Five Continents Volume VIII (IARC Scientific Publications No. 155, 2002, Chapter 5. Comparability and quality of data, D.M. Parkin and M. Plummer). Tests are performed for incidence ASRs, MV (%), and DCO (%).

Figures

Figure 1. Map of the Northwestern Federal District of Russia with bordering regions and countries and corresponding population as of Jan 1 2019. Nenets Autonomous Okrug is an autonomous region of is an autonomous region of Arkhangelsk Oblast with a population of ~ 44 000 people included in the Arkhangelsk oblast population.

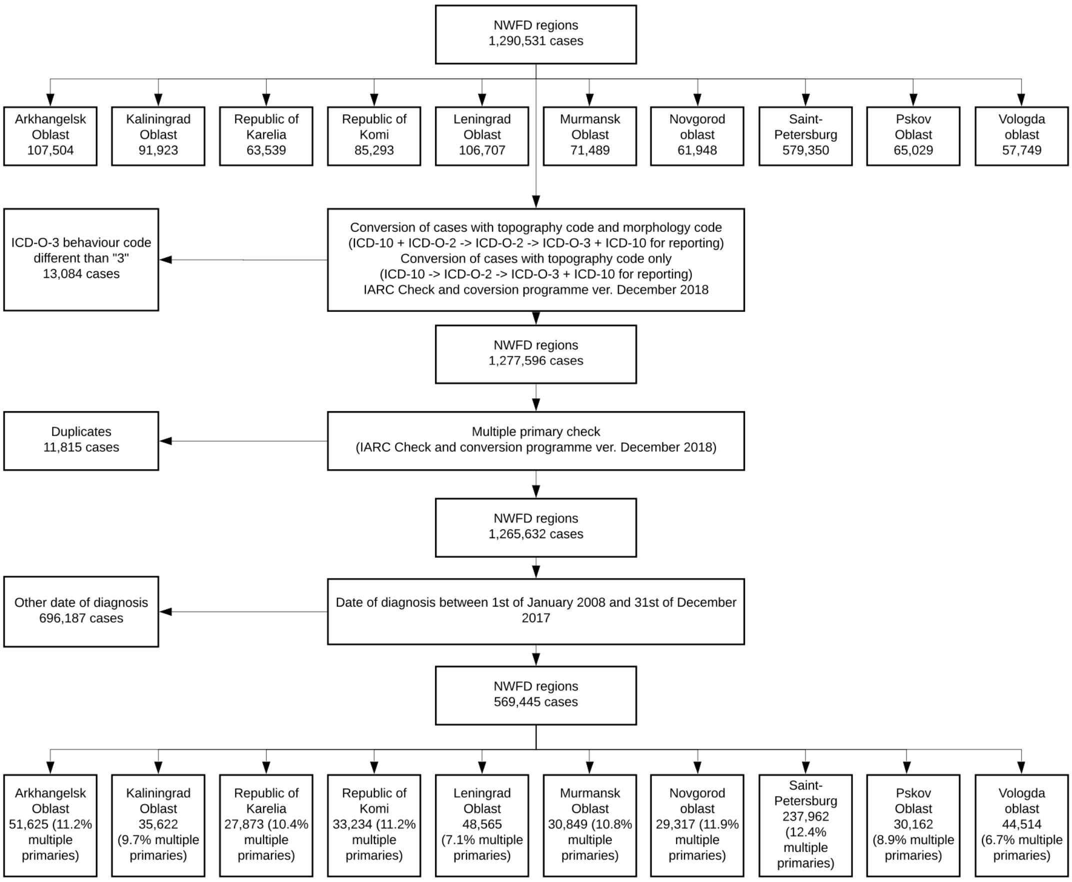

Figure 2. Processing of the cancer registry data.

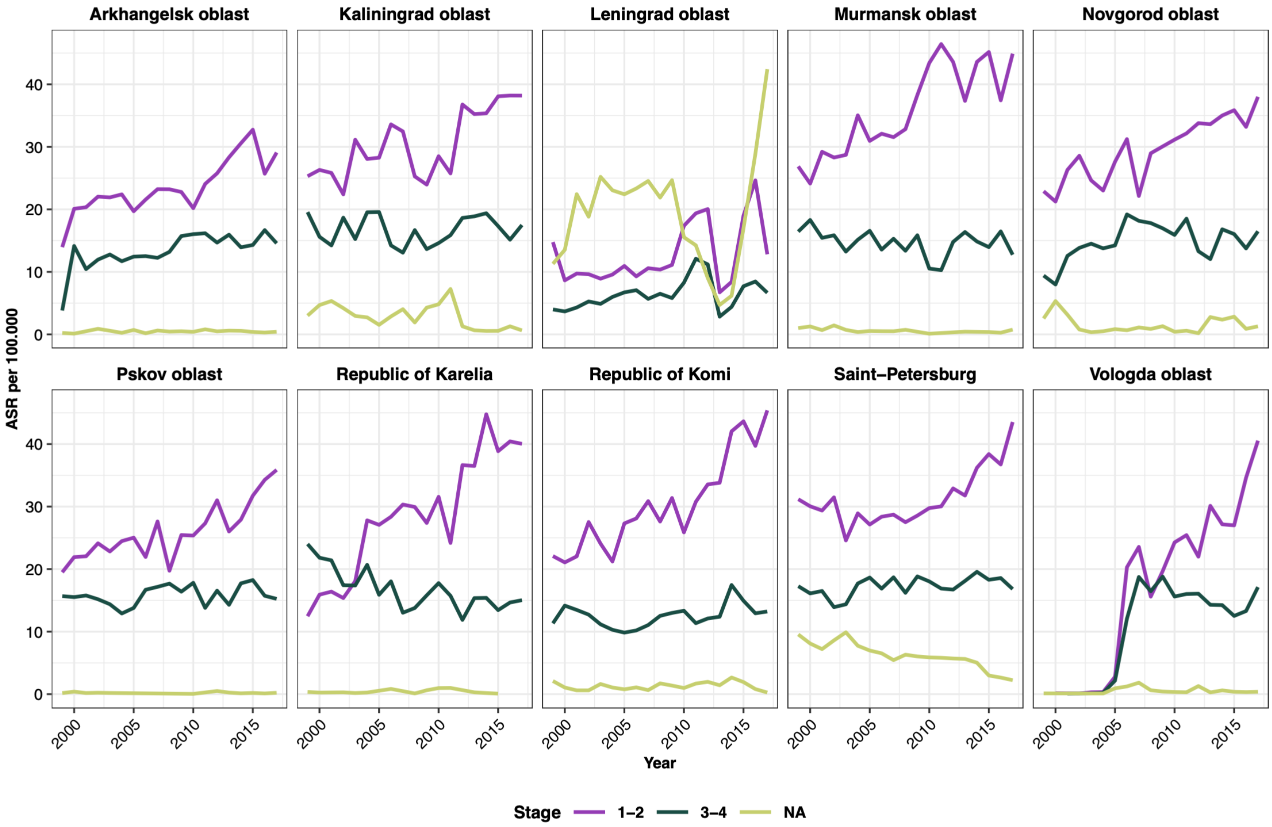

Figure 3. Breast cancer incidence ASRs per 100,000 by stage (localized (1-2) and advanced (3-4) stage), regions of the NWFD, 1993-2017.

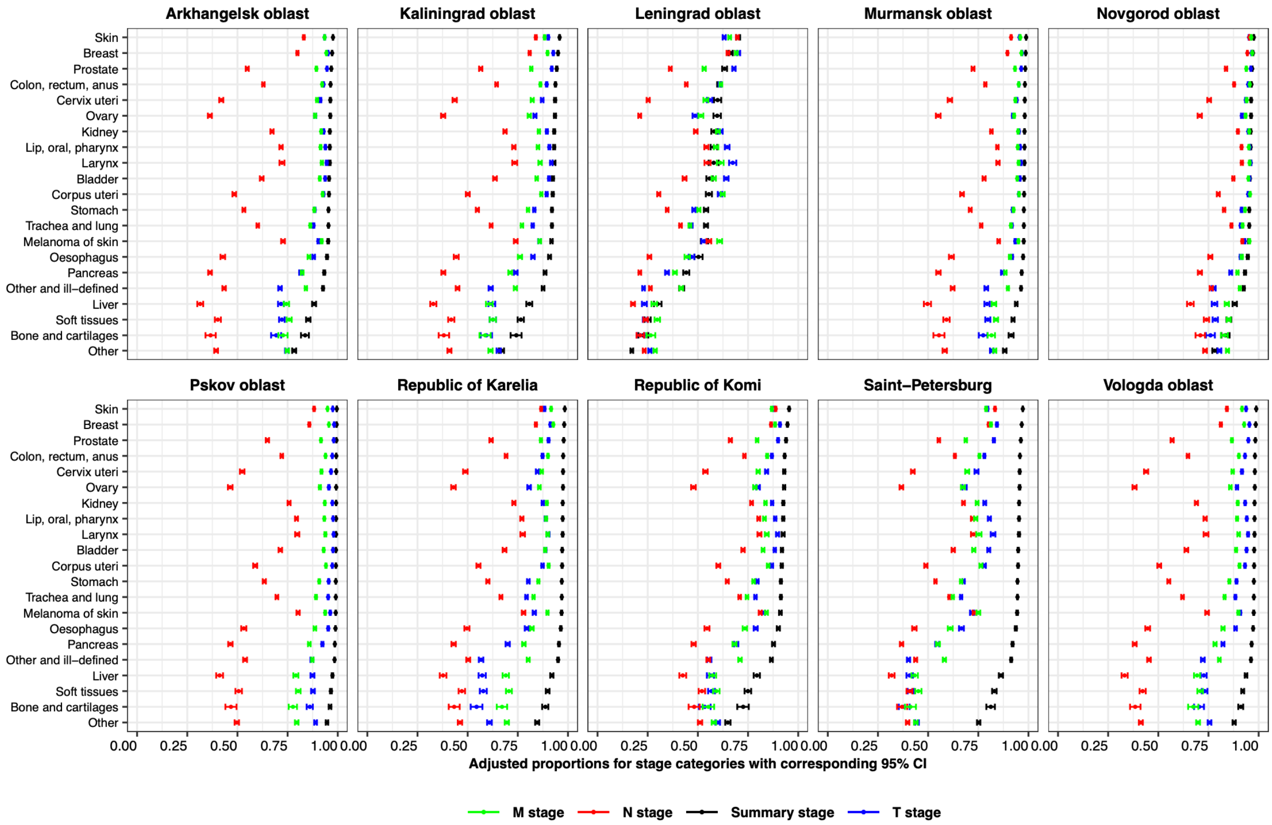

Figure 4. Estimated proportions for the presence of UICC/AJCC stage categories with corresponding 95% CI values by cancer type and regions of the Northwestern Federal District, 2008-2017 (hematological malignancies, lymphomas, CNS tumors, and DCO cases excluded).