



Gastric cancer epidemiology from 2009 to 2019 in Dnipro Region, Ukraine

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ABSTRACT

Background: Gastric cancer (GC) is in top-five the most frequent cancers in Ukrainian males and is the third cause of death among patients with cancer. GC keeps its leading position in cancer ranks despite the decline in incidence and mortality over the last 50 years. Local epidemiological information will help in better targeting medical and public health interventions.

Patients and methods: The data about 8438 patients with newly diagnosed GC between 2009 and 2019 was obtained from Dnipro Cancer Registry.

Results: Incidence decreased from 24.5 to 22.6, mortality decreased from 21.4 to 15.7 (per 100000), death rate increased from 0.64 to 1.04 between 2009 and 2019. Over 11 years of observation incidence was 23.4, mortality was 19.4, death rate was 0.721. Standardised incidence ratio was 1.42, standardised mortality rate was 1.67; age-standardised incidence was 25.5, age-standardised mortality was 21.2 (European standard). Median (95% confidence interval (95% CI)) survival of the patients was 172 (165–178) days. One-year survival rate fluctuated between 27% and 34%. Male sex and older age were associated with higher risk of death (hazard ratio (95% CI) – 1.08 (1.03–1.13) vs females and 1.15 (1.12–1.17) per 10-years increase of age, respectively).

Conclusions: The study describes the trends in epidemiology of gastric cancer in Dnipro region, Ukraine, between 2009 and 2019. The need for the national prevention strategy of GC in Ukraine was identified.

1. Introduction

Gastric cancer (GC) is in top-five the most frequent cancers in Ukrainian males and is the third cause of death among patients with cancer [1]. Ukrainian data are similar to the global trend where GC is in top-five world cancers by incidence and mortality [2,3]. GC keeps its leading position in cancer ranks despite the decline in incidence and mortality over the last 50 years [4]. Local epidemiological information will help in better targeting medical and public health interventions and tailoring healthcare policies, thus improving the outcomes of patients with GC. The present study analyses trends in incidence, mortality, death rate and survival of the patients with gastric cancer from 2009 to 2019 in Dnipro Region, Ukraine. The results of the present study provide an advanced presentation of GC epidemiology that is reported annually by National Cancer Registry of Ukraine [1].

2. Methods

2.1. Data source

The data about the patients were obtained from the database of Dnipro Cancer Registry from 2009 to 2019 years. For the study were selected patients having gastric cancer (GC) – C16 code after International Classification of Diseases, 10th revision (ICD-10). Tumour location was obtained from ICD-10 code: C16.0 – cardia, C16.1 – fundus, C16.2 – body, C16.3 – antrum, C16.4 – pylorus, C16.5–9 – other [5]. Tumour type was presented as adenocarcinoma, carcinoma and other. Tumour differentiation categories included well, moderately, poorly differentiated and undifferentiated tumours. Cancer stage was determined according to TNM classification and included stages from 1 to 4 [6].

The patients were stratified into groups by sex, age at the moment of GC diagnosis and area of residence. Age categories were the following:

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20–29 years, 30–39 years, 40–49 years, 50–59 years, 60–69 years, 70 + years. Patients' area of residence included cities Dnipro and Kryvyi Rih, and 6 raions (districts) of Dnipro region: Dnipro Raion, Kamianske Raion, Kryvyi Rih Raion, Nikopol Raion, Novomoskovsk Raion, Pavlohrad Raion and Synelnykove Raion.

The study was carried out according to the principles of Declaration of Helsinki. The study was approved by Ethical Committee of Dnipro State Medical University (protocol #4 from 06.02.2019). All the data about the patients were anonymised, thus patients' consent for the data analysis was not required.

2.2. Statistical analysis

The data were analysed using LibreOffice and R (version 4.2.1) software [7]. Incidence, mortality and death rate were calculated for each consecutive year and for the period of 2009–2019 years. Mortality was calculated using the formula:

$$\text{Mortality (}i^{\text{th}}\text{ year)} = (\text{Number of deaths among patients diagnosed in }i^{\text{th}}\text{ year} / \text{Population of the region in }i^{\text{th}}\text{ year}) \times 100,000$$

Death rate was calculated using the formula:

$$\text{Death rate} = \text{Number of deaths} / \text{Number of person-years}$$

For the calculation of incidence and mortality by age category and sex were used demographical data from Dnipro statistical centre (population of all ages). Incidence and mortality were presented in units per 100,000 population. Death rate was presented in number of deaths per person-year. Significance of slopes in temporal trends was assessed using linear regression models with calculation of regression coefficient *b* and *p*-value for the model. Standardised incidence ratio (SIR) and standardised mortality ratio (SMR) were calculated for the whole period of observation (11 years) after indirect age standardisation using incidence and mortality values from European continent [8]. Age-standardised incidence and mortality rates were calculated for the whole period of observation (11 years) after direct age standardisation according to 2013 European Standard Population [9] and 2020–2025 World Standard Population [10].

Survival analysis included building Kaplan-Meier curves and assessment of Cox proportional hazards regression models. The starting time point was considered the date of diagnosis of gastric cancer. The end time point was the date of last observation with known condition of a patient. Difference between survival curves was checked using log-rank test. Median survival was presented with 95% CI. One-year survival with 95% CI was calculated after stratification of patients by the year of diagnosis. Calculation of incidence, mortality, death rate and survival analysis were performed after stratification of the patients by sex, age category and place of residence. In case of stratification by sex and age category in survival analysis, hazard ratio with 95% confidence interval (RR (95% CI)) was calculated. Critical value for *p* was set < 0.05.

3. Results

3.1. Population characteristics

To the study were included 8438 patients with newly diagnosed GC (Table 1). Mean age of the patients was 66.5 (66.2–66.7) years. Individuals aged above 70 years and males were the most prevalent categories. 51% of patients lived in the two biggest cities of Dnipro region — Dnipro and Kryvyi Rih. The most frequent localisation of the tumour was body of stomach (34.4%), the less frequent was fundus (0.4%). Among tumour types prevailed adenocarcinomas (63.6%). When the information was available tumours mostly were poorly differentiated (29.2%). Stage 1 was the least frequent known stage of GC at the moment of diagnosis.

Table 1

Clinical and socio-demographic characteristics of patients with gastric cancer.

Parameter	Value
Total number of patients	8438 (100%)
Age at the moment of diagnosis:	
Mean (95% CI)	66.5 (66.2–66.7)
Median (25th;75th percentile)	67.8 (59.0;75.1)
Age category (years), n (%):	
20–29	34 (0.4)
30–39	175 (2.1)
40–49	523 (6.2)
50–59	1591 (18.9)
60–69	2477 (29.4)
70 +	3638 (43.1)
Sex, n (%):	
Males	4878 (57.8)
Females	3560 (42.2)
Area of residence, n (%):	
Dnipro Raion	426[5]
Kamianske Raion	1205 (14.3)
Kryvyi Rih Raion	350 (4.1)
Dnipro City	2677 (31.7)
Kryvyi Rih City	1628 (19.3)
Nikopol Raion	720 (8.5)
Novomoskovsk Raion	432 (5.1)
Pavlohrad Raion	460 (5.5)
Synelnykove Raion	540 (6.4)
Localisation of the tumour, n (%):	
Cardia	1083 (12.8)
Fundus	32 (0.4)
Body	2902 (34.4)
Antrum	1776 (21.0)
Pylorus	457 (5.4)
Other	2188 (25.9)
Tumour type, n (%):	
Adenocarcinoma	5369 (63.6)
Carcinoma	1579 (18.7)
Other	1287 (15.3)
Unknown	203 (2.4)
Tumour differentiation, n (%):	
Well differentiated	446 (5.3)
Moderately differentiated	1534 (18.2)
Poorly differentiated	2467 (29.2)
Undifferentiated	246 (2.9)
Unknown	3745 (44.4)
Stage of GC, n (%):	
1	926 (11.0)
2	2036 (24.1)
3	2280 (27.1)
4	2409 (28.5)
Unknown	787 (9.3)

3.2. Temporal trends in incidence, mortality and death rate

Incidence of GC in Dnipro region from 2009 to 2019 decreased from 24.5 to 22.6 per 100,000 (−7.8%) (Fig. 1, a). The slope of decrease in GC incidence was statistically significant (*b* = −0.26, *p* = 0.01). The peak incidence was observed in 2012 (25.4 per 100,000). The decrease of GC incidence was observed in both sexes. In the age categories from 20 to 59 years there was a steady decline in GC incidence. In 70 + age category GC incidence fluctuated over time. In 60–69 years age category there was an increase in GC incidence (from 61.4 to 63.4 per 100,000). GC incidence in different locations fluctuated around the values for Dnipro region in total, except the value of 42.5 per 100,000 for Pavlohrad Raion in 2016 (Online Table 1).

Mortality from GC in Dnipro region from 2009 to 2019 decreased from 21.4 to 15.7 per 100,000 (−26.7%) (Fig. 1, b). The slope of decrease in GC incidence was statistically significant (*b* = −0.46, *p* < 0.01). The trend for decrease in mortality over time was observed in both sexes and all age categories. Mortality by the area of residence was similar to the incidence: the numbers fluctuated around the values for Dnipro region with the peak value of 39.9 per 100,000 for Pavlohrad

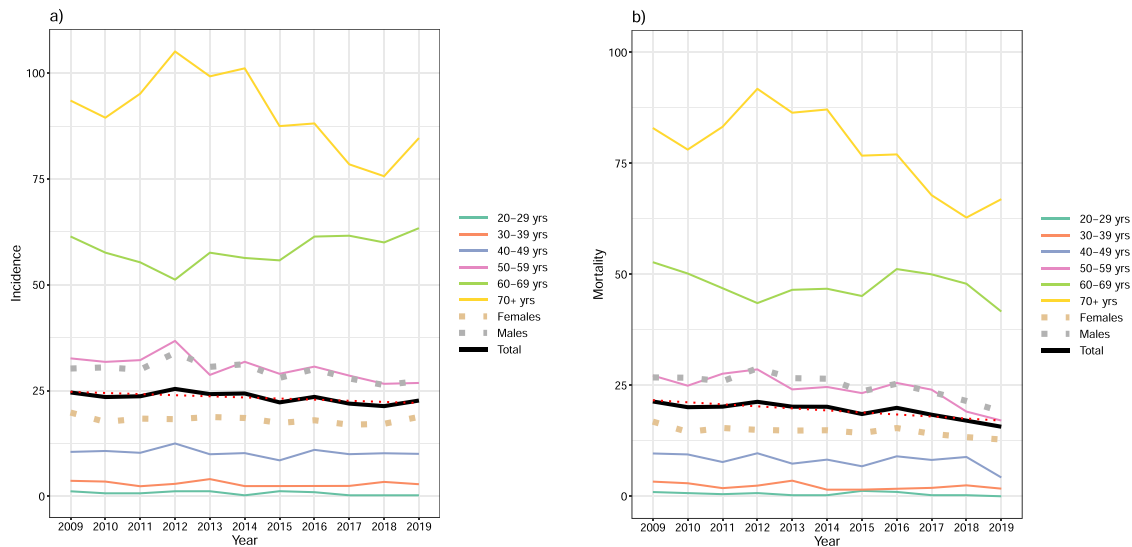


Fig. 1. Incidence (a) and mortality (b) of gastric cancer by sex and age category. Note: Straight dotted red line – linear regression line. Equation for incidence: $y = 555.17 - 0.26x$, $p < 0.01$; for mortality: $y = 941.71 - 0.46x$, $p < 0.01$.

Raion in 2016 (Online Table 2).

Death rate from GC in Dnipro region from 2009 to 2019 increased from 0.64 to 1.04 (Fig. 2, Online table 3, 4). The slope of decrease in GC incidence was statistically significant ($b = -0.46$, $p < 0.01$). The slope of increase of death rate increased dramatically after 2015. The increase of death rate was observed in both sexes and in all age categories. In 20–29 age category the increase of death rate was the greatest and it was non-linear. Death rate stratified by the area of residence followed the trend for the region except the value of 3 for Synelnykove Raion in 2018.

3.3. Incidence, mortality and death rate by region over 11 years of observation (2009–2019)

Epidemiological data of GC in Dnipro region over 11 years of observation was the following: incidence – 23.4 per 100,000, mortality – 19.4 per 100,000, death rate – 0.72. According to 2013 European Standard Population SIR was 1.42; SMR was 1.67; age-standardised incidence was 25.5 per 100,000; age-standardised mortality was 21.2 per 100,000 (Online table 5). According to 2020–2025 World Standard Population SIR was 1.06; SMR was 1.23; age-standardised incidence was 13.6 per 100,000; age-standardised mortality was 11.2 per 100,000.

The highest incidence was observed in Dnipro city (24.6), Kamianske Raion (24.0) and Pavlohrad Raion (23.9, per 100,000) (Fig. 3, a). The highest mortality was observed in Kamianske Raion (21.3) and Pavlohrad Raion (20.6, per 100,000) (Fig. 3, b). The highest death rate was observed in Synelnykove Raion (1.05) (Fig. 3, c). Death rates in Kryvyi Rih and Kryvyi Rih Raion were drastically lower than in the rest of

locations – 0.51 and 0.60. Sex and age structure of different raions are presented in Online table 6.

3.4. Survival of the patients with gastric cancer

Median survival of the patients with GC in our study was 172 (165–178) days (Fig. 4, a). Males had higher risk of death than females – hazard ratio 1.08 (1.03–1.13) (Fig. 4, b). After 4000 days of observation sex difference in survival disappeared. Increase of age category increased the risk of death, relative risk per one category 1.15 (1.12–1.17) (Fig. 4, c). Among the areas of residence the least steep survival curve was in Kryvyi Rih and Kryvyi Rih Raion (S.Fig. 1). Median survival in Kryvyi Rih – 246 (224–268) days, in Kryvyi Rih Raion – 199 (176–239) days. The percentage of patients with GC who survived one year after the diagnosis did not change significantly over time and fluctuated between 27% and 34% (Table 2). Neither changed the sex and age proportions of the patients with GC.

4. Discussion

The present study showed that incidence and mortality of GC gradually declined over the period between 2009 and 2019. The one-year survival rate remained stable, but death rate almost doubled.

The incidence and mortality of GC in Dnipro region follow the worldwide trend on declining [11–13]. This might reflect the advances in prevention of GC, mainly via eradication of H.pylori infection, as well as early diagnosis [12]. As it was expected the incidence and mortality were higher in males and older individuals (Fig. 1). Both Dnipro region population [14] and the patients with GC (Table 2) had stable sex and age structure, so decline in incidence and mortality cannot be attributed to the shifts in population structure. These trends are interesting as currently there is no targeted program for GC screening in Ukraine [15].

Regional differences in incidence, mortality and death rate were not related to the differences in sex or age distribution (Online table 6). In all probability, it could be attributed to random factors. However, the difference in death rates between the raions, which is sometimes two-fold, might require additional investigation.

While there was a decline in incidence and mortality, we observed the doubling of death rate of GC after 2014 (Fig. 2), which might be related to the beginning of military invasion to Ukraine by Russian Federation. Additionally, between 2011 and 2014 the number of doctors per 10000 population in Ukraine halved [16], that could also contribute

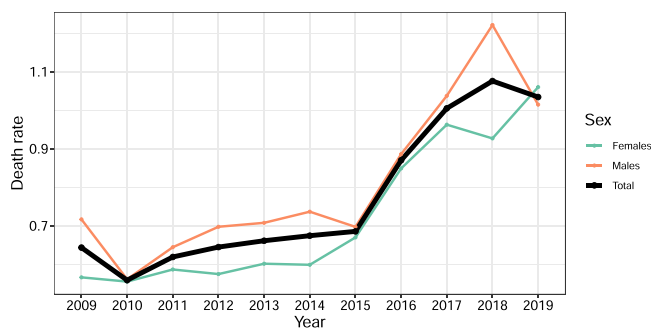


Fig. 2. Death rate from gastric cancer by sex. Note: Straight dotted red line – linear regression line. Equation for death rate: $y = -102.80 + 0.05x$, $p < 0.01$.

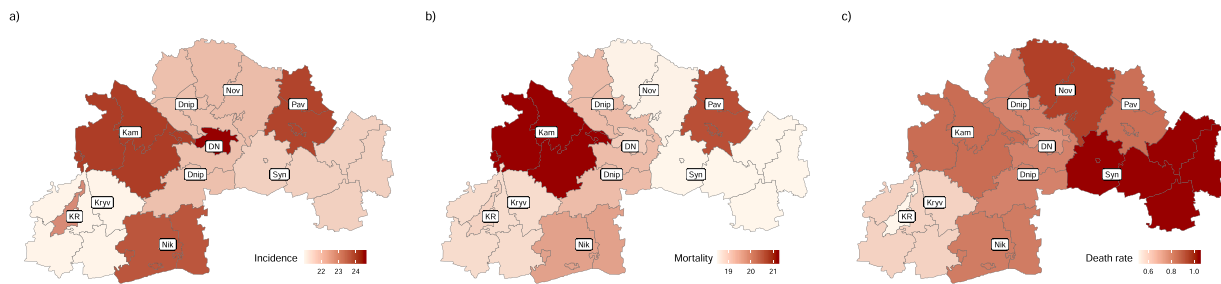


Fig. 3. Incidence (a), mortality (b) and death rate (c) of gastric cancer in Dnipro region during 11 years of observation (data from 2009 to 2019). Note: DN, Dnipro city; Dnip, Dnipro Raion; Kam, Kamianske Raion; KR, Kryvyi Rih city; Kryv, Kryvyi Rih Raion; Nov, Novomoskovsk Raion; Pav, Pavlohrad Raion; Syn, Synelnkove Raion.

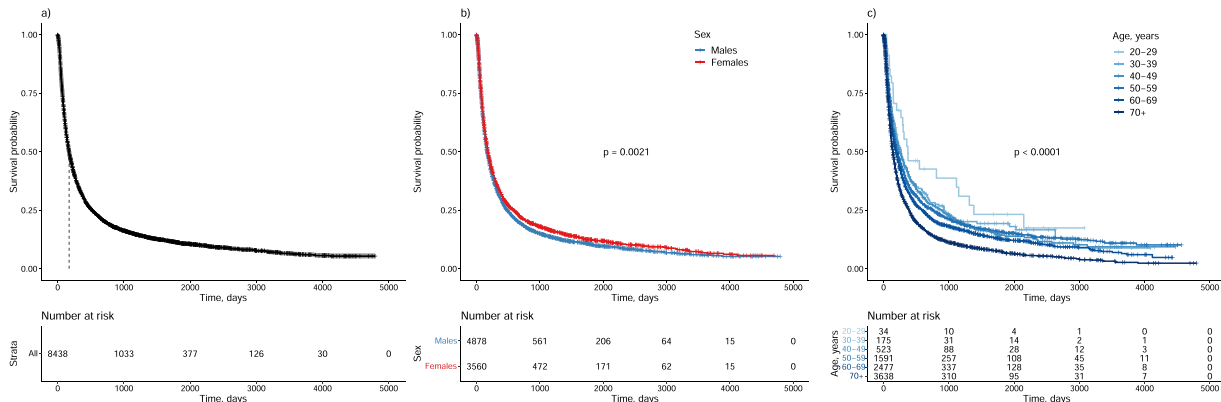


Fig. 4. Kaplan-Meier curves for survival of the patients with gastric cancer: a) overall survival; b) stratified by sex; c) stratified by age category. Note: p value depicts the result of log-rank test for the difference between the curves.

to the deterioration of survival of patients with GC. Importantly, one-year survival rates over time of observation did not change, like it was happening worldwide [12]. We can assume that treatment approach to patients with overt GC remained the same.

According to indirect age standardisation according to World standard incidence and mortality of GC in Ukraine were slightly higher than worldwide (6% and 23% correspondingly). It might be concluded that the efficacy of management of patients with GC in Ukraine is close to the average worldwide. However, according to SIR and SMR (GLOBOCAN, Europe) Ukrainian incidence and mortality were 42% and 67% higher than in Europe. Thus, effectiveness of GC prevention and treatment might be improved using the experience of neighbouring European countries. It can be concluded that the national screening and treatment program of GC in Ukraine is needed. Screening should be conducted in regions with a significant burden of disease in organized, population-based programs [17]. Gastric cancer can be substantially declined via controlling of risk factors such as H.pylori infection, tobacco smoking, and salt-preserved food intake, early detection and prompt treatment of precursor lesions and early cancer [17,18].

5. Strengths and limitations

The study presents epidemiological data from Dnipro region, population of which is above 3 millions of people. This number is compatible or exceeds the population of several European countries.

To the study were only included patients with isolated gastric cancer. Patients with comorbid cancer of other localization were excluded from the study. This may result in difference of the presented data and the information from annual reports of National Cancer Registry of Ukraine.

For calculation of mortality number of deaths of patients who were diagnosed with gastric cancer in the studied year was used, instead of number of deaths per studied year. This was dictated by the peculiarities

of the data organisation, e.g. there were no data of patients who died in 2009 except of those who were diagnosed in 2009. This approach allowed us to use all available data.

The data about the population of Dnipro region by raions was not available for 2009 and 2010 years, thus demographic data of the closest year (2011) were used instead [14]. The data about sex proportions by raion and age categories were available only for 2016–2019 years. The percentage of males and females in the studied categories changed modestly over time. Given that, it was decided to calculate the mean percentage of males and females by raion and age categories from 2016 to 2019, and to recalculate male and female population from the obtained mean percentage for all studied years. The authors believe that performed data transformations did not lead to significant bias of the presented data.

6. Conclusions

The study describes the trends in epidemiology of gastric cancer in Dnipro region, Ukraine, between 2009 and 2019. The need for the national prevention strategy of gastric cancer in Ukraine was identified.

Conflict of interests

The authors declare that they have no conflict of interests.

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Table 2
Demographic data and survival rate of patients with gastric cancer by year of diagnosis registration.

	Year of diagnosis										
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
One year survival, % (95% CI)	0.35 (0.32–0.39)	0.36 (0.33–0.40)	0.35 (0.32–0.39)	0.31 (0.28–0.34)	0.35 (0.31–0.38)	0.33 (0.30–0.37)	0.35 (0.32–0.39)	0.31 (0.28–0.35)	0.29 (0.26–0.33)	0.28 (0.24–0.32)	0.33 (0.29–0.37)
Sex, n (%)											
Males	459 (56.1%)	463 (59.2%)	455 (57.7%)	513 (60.9%)	461 (57.8%)	468 (58.6%)	418 (57.5%)	446 (58.4%)	410 (58.0%)	387 (56.2%)	398 (54.9%)
Females	359 (43.9%)	319 (40.8%)	333 (42.3%)	329 (39.1%)	337 (42.2%)	331 (41.4%)	309 (42.5%)	318 (41.6%)	297 (42.0%)	301 (43.8%)	327 (45.1%)
Age category, n (%)											
20–29	5 (0.6%)	3 (0.4%)	3 (0.4%)	5 (0.6%)	5 (0.6%)	1 (0.1%)	5 (0.7%)	4 (0.5%)	1 (0.1%)	1 (0.1%)	1 (0.1%)
30–39	20 (2.4%)	19 (2.4%)	13 (1.6%)	16 (1.9%)	22 (2.8%)	13 (1.6%)	13 (1.8%)	13 (1.7%)	13 (1.8%)	18 (2.6%)	15 (2.1%)
40–49	49 (6.0%)	50 (6.4%)	48 (6.1%)	58 (6.9%)	46 (5.8%)	47 (5.9%)	39 (5.4%)	50 (6.5%)	45 (6.4%)	46 (6.7%)	45 (6.2%)
50–59	157 (19.2%)	153 (19.6%)	155 (19.7%)	176 (20.9%)	137 (17.2%)	151 (18.9%)	137 (18.8%)	144 (18.8%)	133 (18.8%)	124 (18.0%)	124 (17.1%)
60–69	241 (29.5%)	226 (28.9%)	217 (27.5%)	200 (23.8%)	224 (28.1%)	218 (27.3%)	215 (29.6%)	235 (30.8%)	234 (33.1%)	228 (33.1%)	239 (33.0%)
70 +	346 (42.3%)	331 (42.3%)	352 (44.7%)	387 (46.0%)	364 (45.6%)	369 (46.2%)	318 (43.7%)	318 (41.6%)	281 (39.7%)	271 (39.4%)	301 (41.5%)

CRedit authorship contribution statement

Viktor V. Semenov: study conception, statistical analysis, drafting of the paper; Lilia V. Kriachkova: study conception, statistical analysis, drafting of the paper; Natalia Shestakova: data collection, drafting of the paper; Viktor Khanov: data collection, drafting of the paper; Halyna Donchenko: data collection, drafting of the paper; Olga Balashova: data collection, drafting of the paper; Yulia I. Viklienko: data collection, drafting of the paper.

Data Availability

The research data is available for downloading. Code may be provided upon request.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.canep.2022.102315](https://doi.org/10.1016/j.canep.2022.102315).

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