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Characteristics and Predictors of Ovarian Cancer of Inpatients in USA

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ABSTRACT

Ovarian cancer is the second most common type of gynecologic cancer, and it causes more death than any other female reproductive cancer. It is the 7th most common women's cancer. The objective of the present study is to highlight the risk factors of ovarian cancer related to hospitalization outcomes such as mortality, length of stay, and total medical charges when there is a presence of Congestive heart failure and other complications. Statistical Package for the Social Sciences (SPSS) version 28.0 was used to analyze the present study's data and all outcomes with a p-value less than 0.05 were found to be significant. Overall mortality showed a higher incidence of epithelial ovarian cancer. Patients with HT had a higher death rate with epithelial ovarian cancer than CHF. Increasing age and being white results in an average in length of stay. Those patients with weight loss comorbidities resulted in the greatest mean increase in length of stay. Hispanic population results in an average increase in total cost, while, whites and blacks results in lower cost. The deceased risk of dying was associated with the number of procedures. Increased age and number of diagnoses were associated with an increased likelihood of dying. The increase in procedures and SES increases the length of stay. Among those with hypertension, these predictors are significantly higher. The predictors of mortality assessed by age and number of diseases, which were associated with an increased likelihood of dying.

1. Introduction

Ovarian cancer (OC) is the fifth most diagnosed cancer among females globally [21]. There are three types of ovarian cancers: epithelial, germs and tumours, and trauma cell carcinoma (Stewart et al., 2019). Epithelial cancer is the most predominant pathologic type of cancer of the three types of ovarian cancer. In terms of incidence and mortality, typically, ovarian cancer majorly manifests at a late stage with a five-year survival rate of only 29%. Few cases representing 15% of ovarian cancer are likely to be diagnosed with a localized tumour in stage one and a five-year survival rate of 92% [30]. In this case, ovarian cancer is considered one of the most prevalent and dangerous medical conditions globally [21]. Ovarian cancer accounts for a projected 259000 new cases and nearly 150000 deaths globally each year.

The most alarming rate (11.3 per 100000 and 6.0 per 100000) are majorly reported in central and eastern Europe. In the United States, nearly 21000 cases and 14200 deaths are linked to ovarian cancer in women yearly [19]. Chang, H. Met. al. (2017), talked about current effective practices in diagnosis, prevention, and management [7].

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Armbrust,et. al. (2023) discussed the effect of hypertension (HTN) on progression-free survival (PFS) in patients. Ahmed, et. al., (2022) did an interesting study related to ovarian cancer, cancer stem cells, and current treatment strategies: A potential role of magmas in treatment methods. Results were very interesting [1,2].

Given that ovarian cancer starts deep in the pelvis, they mostly do not have any symptoms until they are in the advanced stages .Additionally, most of the symptoms linked to ovarian cancer are difficult to differentiate from symptoms reported by women who are not diagnosed with ovarian cancer, including fatigue, constipation, and abdominal pain [27]. In view of the limited specificity of ovarian cancer symptoms, nearly 70% of women are constantly diagnosed with it in the advanced stage [27]. Over time, ovarian cancer is likely to spread to the abdominal cavity leading to the build-up of fluids inside the abdomen, commonly known as ascites.

The goal and objective of this study is to determine the impact of risk factors and the predictors and their interactive effects on the length of stay, total charge, and mortality for ovarian cancer patients in the United States. Significance of the study is that it will reveal the similarities and differences of risk factors and predictors of mortality, total charges, and length of hospital stay for stages of different ovarian cancer in patients with comorbidities. In this study, focused on exploring different predictors of ovarian cancer among women and identified based on existing literature, age, gender, race, socioeconomic status (SES), number of procedures, number of diagnoses, and comorbidities as the major risk factors for ovarian cancer. So this study can help to understand how different factors cause ovarian cancer and possible mitigation strategies. The findings could be used to recommend appropriate policies to support early screening for ovarian cancer and reduce the high mortality rate, given that early screening and detection facilities timely treatment and reduced progression into advanced states that are more fatal.

2. Literature Review

2.1. Causes of Ovarian Cancer

Previous studies were indifferent in identifying the cellular origin of ovarian cancer. Still, recent theories have hypothesized that it should not be considered a single disease entity but rather a diverse group of tumors with specific morphologic and genetic characteristics because of its historical differences. Reid et al. (2017) [25] and Chang, L. C (2018) [8] investigated the relationship between genetic abnormalities and syndromes, and EOC using qualitative methods. Cho et, al, (2020 and 2018) [10,11] established that most patients who had EOC came from family backgrounds with a history of cancer from an early age. Over two primary cancers in a single individual have a higher risk of hereditary ovarian cancer syndromes. In addition, the risk of ovarian cancer is higher in women with BRCA1 mutation than in BRCA2 mutation. Mutations within the central region of the *BRCA2* gene (the ovarian cancer cluster region) may be associated with a significantly higher risk of ovarian cancer in women [25].

Crosbie et al. (2021) conducted a qualitative study to explore hereditary causes of ovarian cancer [14]. A sample of 261 women with ovarian cancer participated in the study. After data analysis, the findings showed that mismatch repair deficiency by immunohistochemistry associated with Lynch syndrome (inherited pathogenic germline autosomal dominant mutation in one of the DNA mismatch repair genes) was common in most participants [14]. In addition, most Lynch syndrome tumors were of endometrioid histological subtype. The findings show that Lynch syndrome is hereditary through family, and it may cause ovarian cancer. Liu et al. (2019) conducted a literature review using 36 articles to investigate the link between menopausal hormone replacement and ovarian cancer [31]. Chovanec et. al (2017) researched on long-term toxicity of cisplatin in germ-cell tumor survivors [12].

Some findings revealed a positive association of menopausal HRT with the risk of ovarian cancer, which may increase the risk of serious and endometrioid tumors [31]. In addition, high levels of gonadotropins during menopause act as a promoter on the affected ovarian tissue, and also estrogen-induced ovarian cell proliferation may stimulate the proliferation of ovarian surface epithelial cells, and progesterone could promote the apoptosis of ovarian cells, which may result in increased ovarian cancer tumors [31]. Burzawa, et. al. (2011) evaluated insulin resistance among endometrial cancer patients [6].

Park et al. (2021) [24] conducted a qualitative study exploring the impact of obesity on women. A total of 2,708,938 participated in the research. Multivariate analyses revealed that the risk of ovarian cancer gradually increased as the body mass index (BMI) classification increased from underweight to class II obesity ovarian cancer [24]. Class II obesity was significantly associated with increased risks in post-menopausal and pre-menopausal women [24].

Dixon et al. (2018) [17] pioneered a study investigating the link between height and ovarian cancer using a sample of 39 398 women. Dixon et al. (2018) [17] established that genetically predicted size was associated with increased ovarian cancer risk, and taller women with a genetic propensity had the highest risk of ovarian cancer [17].

Coleman et al. (2020) [13] intended to investigate the relationship between family history and ovarian cancer using qualitative methods. Coleman et al. (2020) [13] found that a family history of ovarian cancer in first-degree biological (mother, sister) and other relatives increases a woman's risk of developing ovarian cancer. According to Coleman et al. (2020) [13], inherited genetic mutations account for approximately 5% to 25% of all ovarian carcinomas. For example, women with a *BRCA1* mutation have a lifetime risk of 35% to 60% of developing ovarian cancer. *PALB2*, *BRIP1*, *BARD1*, *RAD51C*, and *RAD51D* are other germline mutations that present vulnerability to ovarian cancer because they encode DNA repair proteins in the Fanconi anemia BRCA pathway [13].

Likewise, Rosenthal et al. (2017) [26] and Derquin, et al (2020) [16] pioneered a study exploring the effectiveness of ovarian cancer screening on patients with genetic causes of cancer through qualitative methods. A sample of 4,348 women underwent screening. The findings revealed that inherited mutations in *BRCA1* and *BRCA2* and Lynch syndrome (LS) are a significant risk of ovarian cancers, and annual screening of ovarian cancer that uses a cutoff for the serum tumor marker cancer antigen 125 (CA-125) was associated with improved survival (Rosenthal et al., 2017) [26]. Similar to Coleman, Menon et al. (2018) [13,22] conducted a qualitative study to investigate the benefits of screening patients with inherited OC mutations. Menon et al. (2018) [22] reported that BRCA1 and two mutations are the most common conferring a lifetime (cumulative) risk of invasive epithelial ovarian cancer. Women who underwent screening for serum CA 125 (35 units/mL or greater cutoff) and trans-vaginal ultra-sonography had a higher five-year survival rate.

Torng (2017) [29], exploring the association between endometriosis and ovarian cancer through a systematic review using 28 articles, found that endometriosis is associated with ovarian cancer (EAOC) because of particular histological subtypes of ovarian epithelial carcinoma to some specific molecular aberrations. Epithelial ovarian cancer cases reported in women with endometriosis may be because of high heterogeneity in a meta-analysis. Patients with endometriosis reported increased endometrioid carcinoma, clear cell carcinomas, and less serous carcinoma. Bouchard et. al. (2020) [4] reported on Oncologic outcomes and morbidity following heated intraperitoneal chemotherapy at cytoreductive surgery for primary epithelial ovarian cancer.

Bulun et al. (2019) [5] investigated how mutations in patients with endometriosis cause ovarian cancer. After data analysis, Derquin, et. Al. (2020) [16] established that mutations in PIK3CA, KRAS, ARID1A, and other genes were found in the epithelium of intrauterine endometrial tissue, ovarian, and intra-ovarian pelvic endometriosis tissue, ovarian cancers linked to endometriosis (clear cell and endometrioid type), and other epithelial ovarian cancers. Bulun et al. (2019) [5] also found that a high concentration of estrogen in the ovary may exert an additional and direct genotoxic effect on DNA which may cause the accumulation of additional mutations and malignant transformation in already mutated endometriotic epithelial cells in an ovarian endometrioma. An additional mutation in already mutated endometriotic epithelial cells may initiate epithelial ovarian cancer. Temkin et al. (2019) and Daniele et. al, (2021) [15,28] performed a literature review using 52 articles to explore the role of menopausal hormone stimulation in ovarian cancer. Data analysis showed that ovarian cancer risk was significantly increased in current users of the menopausal hormone, especially in women who used both estrogen-only and estrogen-progestogen preparations (Temkin et al., 2019) [15]. Arora, et. al, (2018) presented about long-term mortality among women with epithelial ovarian cancer [3].

Zhang et al. (2021) [32] conducted a study to explore the association between estrogen and progesterone in menopausal hormones and ovarian cancer [32]. Zhang et al. (2021) established that exogenous estrogen and progesterone in the ovaries are associated with increased proliferation and apoptosis inhibition within the ovary [32]. Fallopian tubes and estrogens provide a microenvironment conducive to tumor development by enhancing local vascular supply and favoring an immunosuppressive environment. Foong and Bolton (2017) [18] conducted a systematic review using 43 articles to investigate the relationship between ovarian cancer and obesity. Obese women are at increased risk of ovarian cancer, which additional genetic and environmental factors may influence. Momenimovahed et al. (2019) [23], conducted a literature review exploring the association between ovarian cancer and age. The results revealed that epithelial ovarian c45ancer is an age-related disease mainly considered postmenopausal in women over 65 years. Older age in ovarian cancer, Chiofalo et. al. (2019) [9], is associated with more advanced disease and a lower survival rate.

Zhang et al. (2019) [31] proposed exploring risks associated with age and ovarian cancer. Ovarian cancer was associated with a family history of ovarian cancer, especially where the mother and sister had a history of ovarian cancer. For others, concordant familial risks were highest for mucinous ovarian tumor cancer, with some discordant associations such as endometrioid cancer. Iversen et al. (2018) [20] conducted a qualitative study investigating the relationship between hormonal contraceptives and ovarian cancer. A sample of 1879227 women took part in the research. Participants who frequently used hormonal contraception reported cases of ovarian cancer. Still, contemporary combined hormonal contraceptives were associated with decreased ovarian cancer risk in women of reproductive age. As evidenced by the above literature, the significant causes of ovarian cancer include age, body mass, abnormal genetic syndromes, family history with cancer, height, and menopausal hormones, which have risk factors that may lead to different types of ovarian cancer.

3. Research Design and Methods

The study utilized the National (Nationwide) Impatient Sample (NIS), which is part of the Healthcare Cost and Utilization Project (HCUP). This data was taken for the years 2010 to 2012. The data source is an inpatient dataset produced every year. The NIS is a publicly available all-payer inpatient health care dataset with national estimates of inpatient stays. NIS is a Federal-State-Industry partnership sponsored by the Agency for Healthcare Research and Quality (AHRQ). The data was in the format of SPSS. SPSS is an IBM Statistics software version 28.0. For analysis purposes the IBM-SPSS statistical analysis software was used. All results with p values of less than 0.05 were deemed to be significant. There were N = 62768 patients with ovarian cancer in the dataset.

3.1. Key Predictors for Ovarian Data

The key variables of NIS data included comorbidities, length of stay, SES (socio-economic status), age, race, number of procedures, number of chronic conditions, etc. The dependent variables of the present study are the length of hospital stay, total charges, and incidence of mortality. Patients' demographic characteristics (age, gender, race, etc.), household income, comorbidities, and other clinical variables were considered independent variables. The comorbidities mainly addressed in this study are hypertension and congestive heart failure. Multinomial logistic regression was used to determine the predictors of mortality, while multiple linear regression was used to determine the predictors of total charge and length of stay.

4. Research Methodology and Research Results

4.1. Incidence of Disease by the Age, Gender and Race/Ethnicity

4.1.1. Age from 2010- 2012

The ages of patients ranged from 0 to 103 (M = 45.75, SD = 18.06). The ages appeared to follow a normal distribution as assessed by visual inspection of a histogram.

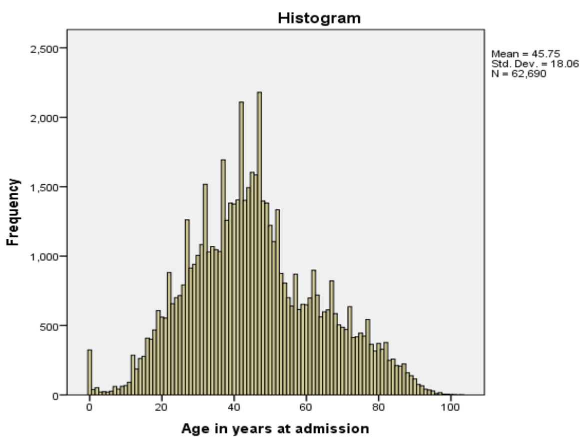

Figure 1: Histogram Depicting Distribution of Ages among Ovarian Cancer Patients distribution.

4.1.2. Gender from 2010 to 2012

There were 62319 (99.3%) females among ovarian cancer patients. There were 282 (0.4%) that identified with a male.

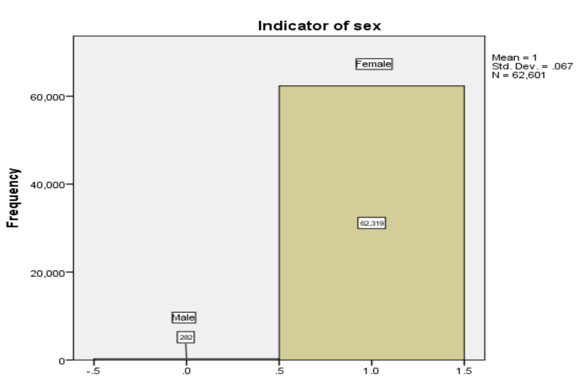

Figure 2: Bar Chart Representing Gender of Ovarian Cancer Patients.

4.1.3. Race/Ethnicity from the year 2010 to 2012

Regarding race, most were White, 36,201 (57.7%). This was followed by Black, 8414 (13.4%); Hispanic, 7209 (11.5%); Asian, 1692 (2.7%).

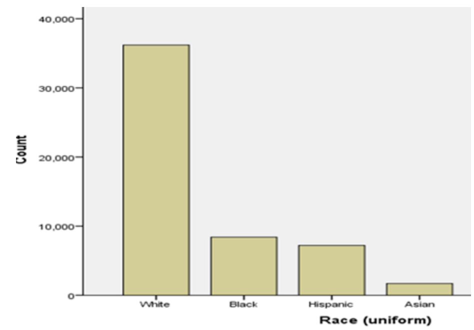

Figure 3: Bar Chart Depicting Race.

4.2. Socioeconomic Status (SES)

SES was measured by using the median household income national quartile for patients' zip code. Most were in the first quartile, 16,246 (25.9%). This was followed by the second quartile, 15,291 (24.4%); the third quartile, 15,397 (24.5%); and the fourth quartile, 14,488 (23.1%). There were 1346(2.1%) instances of no response.

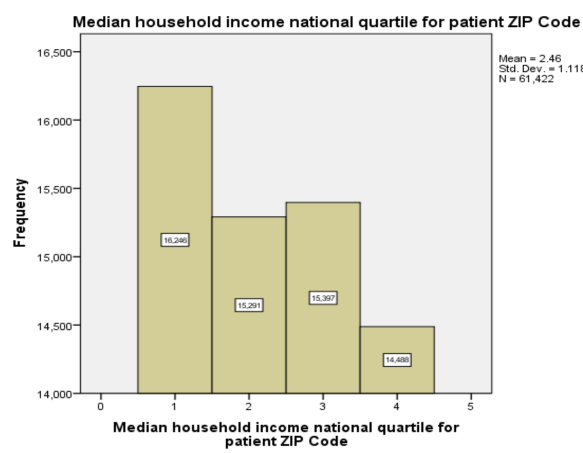

Figure 4: Median Household Income National Quartile of Ovarian Cancer Patients.

4.3. Type of Ovarian Cancer

In this sample, there were three types of cancer under consideration: EOC (epithelial ovarian cancer), SCC (stromal cell carcinoma), and GCT (germ cell tumor). Most were SCC (76.2%). This was followed by EOC (23, 7%) and GCT (0.1%).

4.4. Mortality

Out of the N = 62, 768 ovarian cancer patients, 762 (1.2%) died and 61,998 (98.88%) did not die.

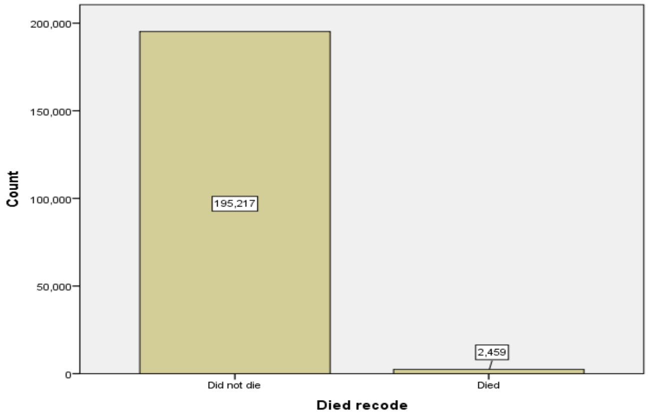

Figure 5: Bar chart Depicting Mortality of Ovarian cancer Patients.

The association between mortality and type of ovarian cancer (EOC -epithelial ovarian cancer, SCC-stromal cell carcinoma, GCT - germ cell tumor) assessed by conducting Chi square tests of association in order to address this first research question Is there an association between mortality and type of ovarian cancer. The results of the Chi-square test was significant, $\chi^2(2) = 505.628$, $p < .001$. There was a significant association between mortality and type of ovarian cancer.

Table 2: Chi-Square Tests.

Chi-Square Tests			
	χ^2	*df*	*P*
Pearson Chi-Square	505.628	2	<.001
Likelihood Ratio	488.849	2	<.001
Linear-by-Linear Association	504.647	1	<.001
N of Valid Cases	20075		

Table 3: Mortality by Cancer Stage Tabulation.

Mortality by Cancer Stage Tabulation					
					Total
		EOC	SCC	GCT	
Died during hospitalization	No	5606	14243	8	19857
	Yes	213	5	0	218
Total		5819	14248	8	20075

4.5. Length of Stay and Total Charge

Length of stay of patients ranged from zero to 29 days (M = 3.91, SD = 5.27). The total charge for services ranged from \$108.00 to \$1,401,187 (M = \$32,738, SD = \$43,109.00). Both length of stay and total charges were highly positively skewed.

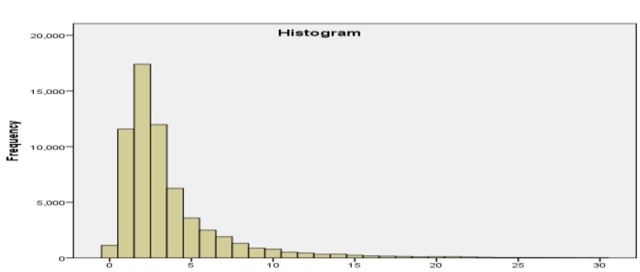

Figure 6: Histogram of Length of Stay of Ovarian Cancer Patients.

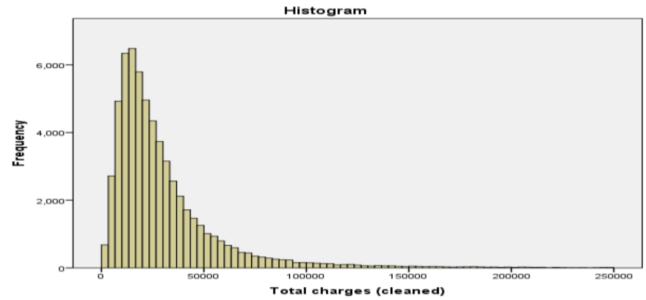

Figure 7: Histogram of Total Charge for Ovarian Cancer Patients.

4.6. Comorbidities

There were several comorbidities measures included in the NIS data set. The top five were hypertension, 16,995 (27.1%); deficiency anemia, 9335 (14.9%); Fluid/Electrolyte disorders, 9318 (14.8%); Chronic pulmonary disease, 6956 (11.1%); and Obesity, 6481 (10.3%). The complete list of comorbidities is provided in Table 1.

Table 1: Comorbidity Measures.

Comorbidities	N	%
Hypertension	16995	27.1%
Deficiency anemia	9335	14.9%
Fluid /electrolyte disorders	9318	14.8%
Chronic pulmonary disease	6956	11.1%
Obesity	6481	10.3%
Depression	5893	9.4%
Hypothyroidism	5700	9.1%
Diabetes, uncomplicated	5682	9.1%
Metastatic cancer	4199	6.7%
Solid tumor without Metastasis	4041	6.4%
Weight loss	2254	3.6%
Other neurological disorders	2006	3.2%
Chronic blood loss anemia	1833	2.9%
Psychoses	1768	2.8%
Coagulopathy	1661	2.6%

4.7. Number of Procedures

The number of procedures ranged from zero to 31 (M = 2.47, SD = 2.26). The skewness and kurtosis values suggested that the deviation from normality is not severe. As skewness and kurtosis values were in acceptable ranges.

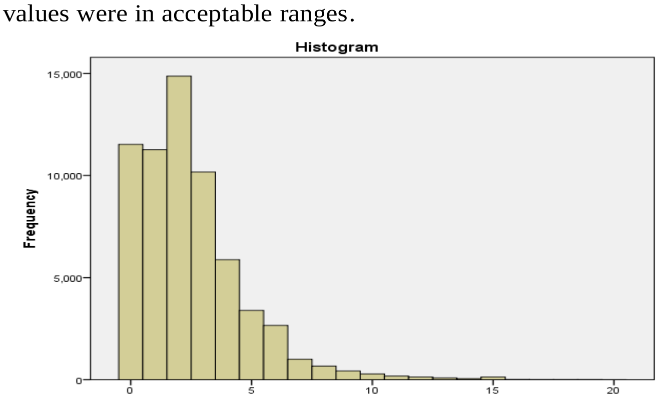

Figure 8: Histogram of the Number of Procedures.

4.8. Mortality And Type Of Ovarian Cancer Patient With Congestive Heart Failure

The association between mortality and type of ovarian cancer with CHF was assessed by conducting Chi square tests.

Table 4: Chi-Square Tests.

	χ2	df	P
Pearson Chi-Square	9.115	2	.003
Continuity Correction[b]	7.841	2	.005
Likelihood Ratio	11.195	2	.001
Fisher's Exact Test			
Linear-by-Linear Association	9.089	2	.003
N of Valid Cases	356		

Table 5: Mortality by Cancer Stage of Patients with CHD patients with CHF.

		EOC	SCC	GCT	Total
Died during hospitalization	No	202	130	0	332
	Yes	22	2	0	24
Total		224	132	0	356

More people died in the EOC category than in other types of ovarian (EOC- 22, SCC- 1, GCT-0).

4.9. Mortality and Type of Ovarian Cancer Patient with Hypertension (HT)

The association between mortality and type of ovarian cancer with HT was assessed by conducting Chi-square test.

Table 6: Chi-Square Tests.

	χ2	df	P
Pearson Chi-Square	104.946[a]	2	<.001
Likelihood Ratio	122.761	2	<.001
Linear-by-Linear Association	104.709	1	<.001
N of Valid Cases	5695		

Table 7: Mortality by Cancer Stage of Patients with HT.

		EOC	SCC	GCT	Total
Died during hospitalization	No	2301	3310	3	5614
	Yes	79	2	0	81
Total		2380	3312	3	5695

4.10. Predictors of the Length of Stay of Patients with Ovarian Cancer

There were no significant outliers in the regression residuals and no multicollinearity, as indicated by all variance inflation factors below 5.0. There was approximate normality of regression residuals and homoscedasticity and collective linearity (scatterplot). Histogram shows an approximate symmetric distribution mound-shaped distribution, which justifies approximate normality. Scatterplot suggests homoscedasticity and collective linearity between the independent variables and the dependent variable.

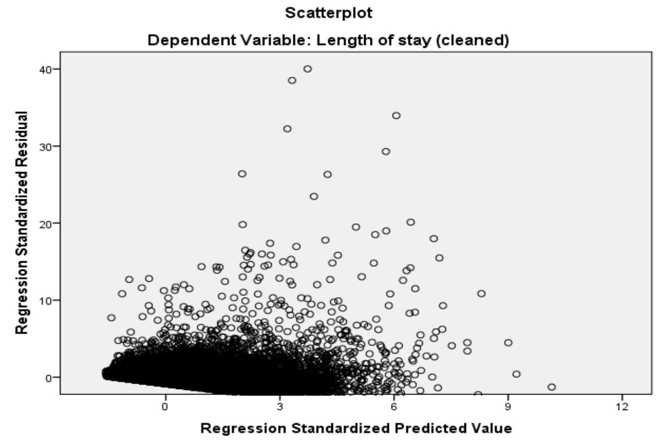

Figure 9: Scatterplot length of stay.

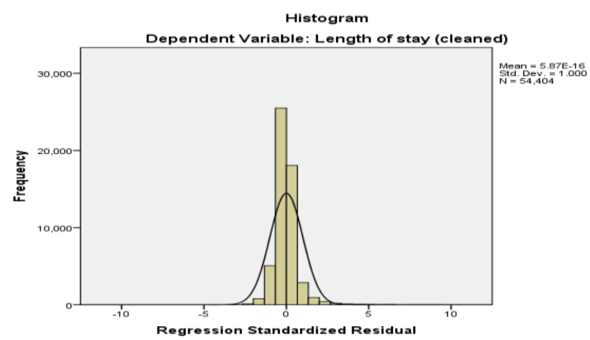

Figure 10: Histogram length of stay.

Multiple regression was conducted with SPSS software, with independent variables of age, race, SES, comorbidities, number of diagnoses, and number of procedures & dependent variable length of stay. The overall model was significant, $F(31, 54403) = 686.809$, $p < .001$.The increasing number of diagnoses ,procedures, and SES results in an average increase in length of stay. Increasing age and being White results in an average decrease in length of stay. The comorbidity that had that most significant effect was weight loss which had the largest standardized regression coefficient ($b = 3.519$, $p < .001$). The comorbidity that had that most significant effect was weight loss which had the largest standardized regression coefficient ($b = 3.519$, $p < .001$). Those patients with weight loss comorbidities resulted in the greatest mean increase in length of stay.

4.11. Predictors of the Length Of Stay Of Patients With Ovarian Cancer with Hypertension

Multiple regression was conducted with SPSS software which included the same independent variables as previous. However, only those that had hypertension were selected. The nonrandom pattern in the scatter plot of suggests homoscedasticity and collective linearity between the independent variables and the dependent variable. There were no significant outliers in the regression residuals and no multicollinearity, as indicated by all variance inflation factors below 5.0.

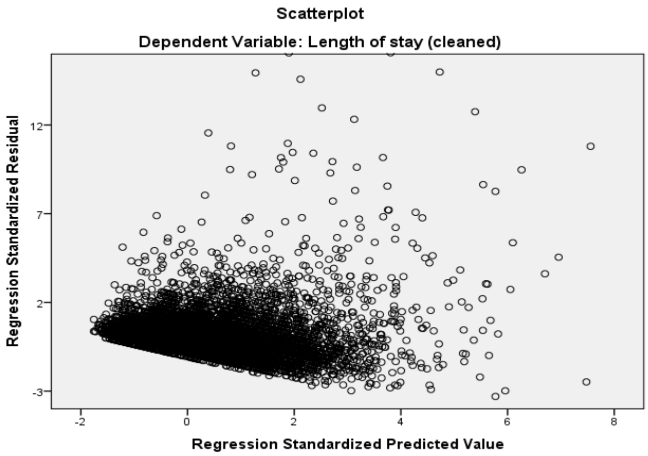

Figure 11: standardized Regression.

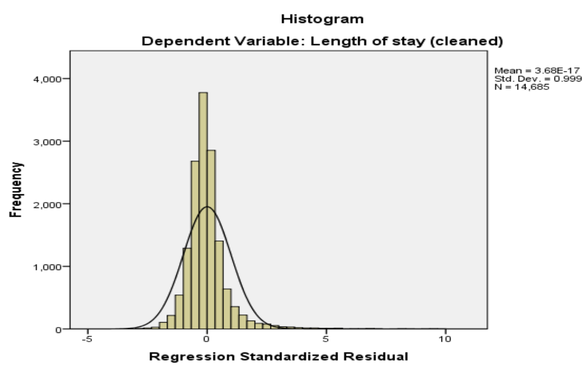

Figure 12: Regression Residual.

The overall model was significant, $F(16, 14684) = 442.684$, $p < .001$The increasing number of diagnoses, procedures, age, and SES results in an average increase in length of stay. Being White results in an average decrease in length of stay. Those patients with weight loss comorbidities resulted in the greatest mean increase in length of stay.

4.12. Comorbidities with length of hospital stay with HT

Table 8: Comorbidities.

Variable	B	SE	β	*t*	*p*	Tolerance	VIF
(Constant)	-.945	.166		-5.711	.000		
NDX	.245	.010	.226	25.743	.000	.595	1.680
NPR	.706	.015	.324	45.865	.000	.918	1.089
CM_WGHTLOSS	3.145	.174	.129	18.065	.000	.902	1.109
CM_LYTES	1.344	.098	.103	13.753	.000	.817	1.223
CM_TUMOR	1.284	.127	.072	10.121	.000	.899	1.112
CM_METS	1.257	.130	.070	9.645	.000	.879	1.137
White	-.594	.083	-.052	-7.164	.000	.887	1.127
CM_PARA	2.817	.404	.048	6.972	.000	.985	1.016
CM_OBESE	-.544	.104	-.037	-5.229	.000	.899	1.112
CM_PULMCIRC	1.564	.265	.041	5.900	.000	.961	1.040
CM_CHF	.759	.179	.030	4.238	.000	.908	1.102
FirstQuartile	.398	.083	.033	4.782	.000	.957	1.045
CM_COAG	.843	.203	.029	4.158	.000	.950	1.053
CM_ANEMDEF	.385	.097	.029	3.987	.000	.890	1.124
AGE	.009	.003	.028	3.578	.000	.770	1.299
CM_NEURO	.463	.186	.017	2.489	.013	.973	1.028

4.13. Predictors of total charges of Patients with Ovarian Cancer

Multiple regression was conducted with SPSS software which included the same independent variables as previous. The dependent variable was a total charge. The nonrandom pattern in the scatter plot of suggests homoscedasticity and collective linearity between the independent variables and the dependent variable. Multiple regression was conducted with SPSS software which included the independent variables of age, race, SES, comorbidities, number of diagnoses, and number of procedures & the dependent variable was a total charge.

The overall model was significant, $F(27, 53221) = 442.684$, $p < .001$. The increasing number of diagnoses, procedures, age, and being Hispanic results in an average increase in total cost. Being White or Black results in an average decrease in total cost. The comorbidity that had that most significant effect was weight loss which had the largest standardized regression coefficient ($b = 21352.657$, $p < .001$). Those patients with weight loss comorbidities resulted in the greatest mean increase in total charge.

Table 8: Comorbidities.

Variable	B	SE	B	*t*	*p*	Tolerance	VIF
(Constant)	8164.474	799.633		10.210	.000		
NPR	7696.833	75.926	.396	101.372	.000	.874	1.144
NDX	1817.379	50.097	.194	36.277	.000	.465	2.150
CM_WGHTLOSS	21352.657	930.096	.089	22.957	.000	.885	1.130
CM_LYTES	8411.445	506.080	.068	16.621	.000	.798	1.253
Hispanic	4256.601	777.362	.032	5.476	.000	.384	2.603
CM_METS	9128.324	707.276	.051	12.906	.000	.846	1.182
AGE	-134.790	11.379	-.055	-11.846	.000	.617	1.619
CM_CHF	11443.593	1185.986	.037	9.649	.000	.908	1.101
CM_TUMOR	6517.147	702.620	.036	9.275	.000	.884	1.131
CM_PARA	18036.682	2079.138	.032	8.675	.000	.974	1.027
CM_COAG	9283.202	1040.581	.034	8.921	.000	.943	1.060
White	-5657.613	665.740	-.061	-8.498	.000	.261	3.831
CM_PULMCIRC	11400.553	1453.321	.029	7.844	.000	.956	1.046
CM_BLDLOSS	-6981.640	978.537	-.026	-7.135	.000	.977	1.023
CM_DEPRESS	-3473.728	578.020	-.023	-6.010	.000	.935	1.069
First Quartile	-2189.839	399.397	-.022	-5.483	.000	.839	1.192
CM_OBESE	-2173.089	561.983	-.015	-3.867	.000	.922	1.085
CM_NEURO	4037.118	944.809	.016	4.273	.000	.954	1.048
Second Quartile	-1622.247	402.247	-.016	-4.033	.000	.879	1.138
CM_VALVE	-4769.757	1157.516	-.015	-4.121	.000	.958	1.044
CM_HTN_C	-1452.361	428.878	-.015	-3.386	.001	.723	1.383
Black	-2636.244	766.836	-.021	-3.438	.001	.348	2.873
CM_CHRNLUNG	-1604.648	537.949	-.011	-2.983	.003	.935	1.070
CM_HYPOTHY	-1605.472	584.700	-.010	-2.746	.006	.931	1.074
CM_LYMPH	-9968.235	4157.408	-.009	-2.398	.017	.997	1.003
CM_AIDS	12443.809	5577.497	.008	2.231	.026	.996	1.004
CM_ALCOHOL	3408.956	1603.295	.008	2.126	.033	.980	1.020

4.14. Predictors for total charges of patients with ovarian cancer with Congestive heart failure

There was approximate normality of regression residuals (histogram) and homoscedasticity and collective linearity (scatterplot). Histogram approximate symmetric distribution mound-shaped distribution, which justifies approximate normality. Additionally, the nonrandom pattern in the scatter plot suggests homoscedasticity and collective linearity between the independent and dependent variables. There were no significant outliers in the regression residuals and no multicollinearity, as indicated by all variance inflation factors below 5.0.

The overall model was significant, F(10, 1103) = 70.536, p < .001. The increasing number of diagnoses, procedures, and being Hispanic results in an average increase in total cost. The comorbidity that had the most significant effect was weight loss which had the largest standardized regression coefficient (b = 22286.352, p < .001).Those patients with weight loss comorbidities resulted in the greatest mean increase in total charge.

Table 10: Total charges of patients with ovarian cancer with CHF and comorbidities.

Variables	B	SE	Β	*t*	*p*	Tolerance	VIF
(Constant)	-15499.988	6394.448		-2.424	.016		
NPR	14123.750	720.045	.496	19.615	.000	.864	1.157
NDX	2566.123	428.663	.162	5.986	.000	.753	1.329
Hispanic	45497.149	8475.871	.127	5.368	.000	.989	1.011
CM_WGHTLOSS	22286.352	6500.030	.084	3.429	.001	.913	1.095
CM_COAG	25131.287	7925.645	.076	3.171	.002	.951	1.052
CM_RENLFAIL	-16487.463	5640.587	-.071	-2.923	.004	.943	1.061
CM_DEPRESS	-13286.334	6300.953	-.050	-2.109	.035	.972	1.029
CM_DM	-10609.607	4945.732	-.051	-2.145	.032	.968	1.033
CM_BLDLOSS	-23533.933	11448.640	-.049	-2.056	.040	.984	1.017
CM_PERIVASC	-16499.922	8180.814	-.048	-2.017	.044	.959	1.043

4.15. Predictors for total charges of patients with ovarian cancer Hypertension

There were no significant outliers in the regression residuals and no multicollinearity, as indicated by all variance inflation factors below 5.0. Multiple regression was conducted with SPSS and the dependent variable was a total charge. The overall model was significant, F(22, 14338) = 314.942, p < .001.The increasing number of diagnoses, procedures, and being Hispanic results in an average increase in total cost. The comorbidity that had that most significant effect was weight loss which had the largest standardized regression coefficient (b = 18801.359, p < .001). Those patients with weight loss comorbidities resulted in the greatest mean increase in total charge.

Table 11: Total charges of patients with ovarian cancer with HT and comorbidities.

Variable	B	SE	β	t	p	Tolerance	VIF
(Constant)	3176.988	1682.226		1.889	.059		
NPR	8308.308	140.451	.425	59.155	.000	.913	1.096
NDX	1937.566	89.175	.197	21.728	.000	.570	1.753
CM_WGHTLOSS	18801.359	1597.544	.085	11.769	.000	.900	1.111
White	-11863.915	1013.037	-.114	-11.711	.000	.494	2.022
CM_LYTES	7721.019	892.217	.066	8.654	.000	.813	1.231
Black	-8431.323	1193.148	-.068	-7.066	.000	.505	1.980
CM_COAG	9156.759	1853.703	.035	4.940	.000	.949	1.054
CM_PARA	21307.849	3695.908	.040	5.765	.000	.986	1.014
CM_CHF	8868.939	1633.669	.039	5.429	.000	.906	1.104
CM_TUMOR	6264.793	1156.186	.039	5.418	.000	.899	1.112
CM_METS	4779.454	1195.228	.029	3.999	.000	.878	1.140
Third Quartile	2488.888	795.638	.022	3.128	.002	.993	1.007
Native American	-13966.029	4574.205	-.021	-3.053	.002	.963	1.038
CM_PULMCIRC	7428.285	2398.865	.022	3.097	.002	.959	1.042
CM_ANEMDEF	2428.551	883.354	.020	2.749	.006	.884	1.131
CM_LYMPH	-19160.662	6970.833	-.019	-2.749	.006	.997	1.003
CM_AIDS	23592.049	9592.915	.017	2.459	.014	.993	1.007
CM_ALCOHOL	6749.191	3190.264	.015	2.116	.034	.984	1.016
CM_DEPRESS	-2453.154	1041.578	-.017	-2.355	.019	.937	1.067
AGE	-60.774	24.006	-.020	-2.532	.011	.752	1.329
CM_OBESE	-2239.257	957.545	-.017	-2.339	.019	.897	1.115
CM_BLDLOSS	-4562.094	2191.883	-.014	-2.081	.037	.977	1.024

4.16. Predictors for mortality of patients with ovarian cancer

Binary logistic regression analysis is used to predict a dichotomous dependent variable, mortality (died or not died) in this case, based on independent variables. Increased age (b = 0.029, OR = 1.029, p < .001), and number of diagnoses (b = 0.123, OR = 1.31, p < .001) were associated with increased likelihood of dying. Anemia (b = .552, OR = 1.737, p < .001); depression (b = 1.303, OR = 3.679, p < .001); Hypertension (b = 0.605, OR = 2.390, p < .001); hypothyroidism (b = 0.605, OR = 1.832, p = .009); and obesity (b = 0.782, OR = 2.186, p = .024) were associated with increased likelihood of dying.

Table 12: Predictors for mortality of patients with ovarian cancer.

Variable	B	SE	Wald	df	*p*	*OR*
AGE	.029	.005	27.717	1	.000	1.029
NPR	-.186	.025	57.763	1	.000	.830
NDX	.123	.016	58.004	1	.000	1.131
CM_ANEMDEF(1)	.552	.185	8.899	1	.003	1.737
CM_DEPRESS(1)	1.303	.358	13.209	1	.000	3.679
CM_HTN_C(1)	.871	.162	28.822	1	.000	2.390
CM_HYPOTHY(1)	.605	.231	6.861	1	.009	1.832
CM_LYTES(1)	-.790	.160	24.473	1	.000	.454
CM_OBESE(1)	.782	.345	5.130	1	.024	2.186
CM_PULMCIRC(1)	-.972	.240	16.440	1	.000	.379
CM_WGHTLOSS(1)	-.443	.188	5.560	1	.018	.642
Constant	-24.503	13613.289	.000	1	.999	.000

5. Conclusions and Discussions

Ovarian cancer accounts for a disproportionately high number of cancer deaths (given its incidence) due to its poor prognosis. Survival rates are low; only about 45% of women are still alive five years after diagnosis in developed countries. Modest improvements have been seen over recent decades. For example, five-year survival in the early 1980s was 25-39% in the UK, USA, and Australia (Felix et al. 2017). Nevertheless, ovarian cancer survival remains far poorer than for many better-known cancers affecting women, such as breast cancer, which has a five-year survival rate of 91% (Felix et al. 2017). Most women with ovarian cancer (for instance, 79% in the USA are not diagnosed until their cancer is at an advanced stage, having spread beyond the ovary. Women whose cancers are diagnosed at late (advanced) stage have far poorer survival than women whose cancers were an earlier stage at diagnosis (for instance, 29% vs 92% five-year survival for women diagnosed with stage III-IV vs IA-IB cancers (11)), but improving early detection is challenging.

There is a significant association between mortality and type of ovarian cancer, more people died in the epithelial ovarian cancer category than other types of ovarian cancer. The increasing number of diagnoses, procedures, and SES results in an average increase in length of stay. Those patients with weight loss comorbidities resulted in the greatest mean increase in length of stay. Among those with hypertension, these predictors were also significant. The increasing number of diagnoses, procedures, age, and being Hispanic results in an average increase in total cost. These same relationships were found among the congestive heart failure and hypertensive patients. Predictors of mortality were assessed by conducting binary logistic regression. Age and number of diagnoses were associated with increased likelihood of dying. Anemia, Depression, Hypertension, Hypothyroidism and Obesity were associated with increased likelihood of dying.

Length of stay of patients ranged from zero to 209 days (M = 3.91, SD = 5.27). The total charge for services ranged from $108.00 to $1,401,187 (M = $32,738, SD = $43,109.00). Both length of stay and total charges were highly positively skewed. The number of procedures showed a deviation from normality, ranging from zero to 31 (M = 2.47, SD = 2.26). The top five comorbidities measures included hypertension, 16,995 (27.1%); deficiency anemia, 9335 (14.9%); Fluid/Electrolyte disorders, 9318 (14.8%); Chronic pulmonary disease, 6956 (11.1%); and Obesity, 6481 (10.3%). Collectively, the group of tumors known as ovarian cancer is the tenth most common cancer and the fifth most common cause of cancer death among women in high income countries (gross national income per capita over US$12,235 (The World Bank 2020), where incidence rates age-standardized to the world standard population are 8.2 per 100,000 and mortality rates are 4.2 per 100,000 (IARC Global Cancer Observatory 2020). In absolute terms, in 2018 over 295,000 women were diagnosed, and there were nearly 185,000 deaths from the cancer worldwide (IARC Global Cancer Observatory 2020). Age-standardized incidence varies from over 12 per 100,000 (in several eastern and north-eastern European countries) to less than 3 per 100,000 (in a number of African countries) (IARC Global Cancer Observatory 2020), although for some regions low rates may reflect incomplete population coverage by the cancer registry (Dixon et al., 2014).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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