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ORIGINAL RESEARCH

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The global, regional and national epidemiology, incidence, mortality, and burden of ovarian cancer

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Abstract

Background: Ovarian cancer has the highest mortality rate among gynecological malignancies and is associated with poor prognosis. Since the accurate assessment of the global burden along with the trend of cancers contributes to the development of policies, this study aimed to explain the incidence, mortality, and burden of ovarian cancer using the global burden of disease (GBD) 2019 study.

Methods: Epidemiological data have been collected from the study of the GBD 2019. Data were extracted globally for 204 countries and groups based on a socio-demographic index (SDI), WHO regions, continents, World Bank regions, and 22 GBD regions.

Results: In 2019, a total of 294,422 new cases of ovarian cancer were reported. The highest age-standardized incidence rate (ASIR) was reported in areas with higher SDI, World high-income countries, continental Europe, and then America. In GBD regions, the highest age-standardized incidence is in Central Europe. In 2019, a total of 198,412 deaths due to ovarian cancer were reported. The highest ASR death is related to countries with high SDI and the World Bank high-income countries. In 2019, adjusted years of life with disabilities (DALYs) due to ovarian cancer were reported to be 5,359,737, of which 5,205,660 were related to lost years of life (YLLs), and 154,077 were related to years of life with disabilities (YLDs).

Conclusions: In 2019, the highest age-standardized incidence of ovarian cancer, ASR death, and DALYs ASR belong to the high SDI countries. Designing interventions based on risk factors as well as providing preventive approaches to reduce the risk of this cancer, improving the treatment of ovarian cancer, and using appropriate and invasive treatments are recommended.

KEYWORDS

burden, global, incidence, mortality, ovarian cancer

1 | INTRODUCTION

Cancer is the most common cause of death in many countries. Ovarian cancer is the most common gynecological cancer after cervix and uterine cancers.[1] Ovarian cancer has the highest mortality rate among gynecological malignancies and is associated with poor prognosis, low survival rate, and is the most deadly reproductive cancer among women.[2] It is estimated that by 2040, the incidence rate of ovarian cancer will increase significantly.[3] Statistics have shown that the ovarian cancer mortality rate increased by 84.2% between 1990 and 2017.[4] Asymptomatic growth of the tumor, delayed onset of symptoms, and lack of proper screening methods for this cancer have prevented more than 70% of ovarian cancer sufferers from early diagnosis until the advanced stages of the disease. All these factors have led to this cancer being named the "secret killer."[2,5]

According to epidemiological data, the incidence of ovarian cancer varies in different parts of the world. According to the global burden of disease (GBD 2017), Central Europe showed the highest incidence, adjusted years of life with disabilities (DALYs), and standardized mortality rate by age. South and East Asia accounted for the largest percentage increase in incidence rate from 2007 to 2017 which can be attributed to several factors such as the prevalence of risk factors.[6]

Almost all ovarian tumors originate from one of three types of epithelial cells (90%), stromal cells (5%–6%), and germ cells (2%–3%).[7] According to the epidemiological studies, the known risk factors for ovarian cancer include higher age, genetic susceptibility, infertility treatments, and family history. Pregnancy, lactation, and oral contraceptive pills have been mentioned as protective factors.[2] By eliminating risk factors, the incidence of ovarian cancers will be reduced by one-third to two-fifths.[3]

Since the accurate assessment of the global burden along with the trend of cancer contributes to the development of policies, efficient management planning, improved service delivery, targeted resource allocation for diagnostic and treatment measures, and better healthcare decision-making, the use of epidemiological studies is instrumental in achieving these goals.[8] In the present study, epidemiological data including incidence cases, deaths, age-standardized rate (ASR) incidence, lost years of life (YLLs), years of life with disabilities (YLDs), and DALYs, have been collected from the GBD 2019 and presented separately.

2 | MATERIALS AND METHODS

ASRs of the incidence, deaths, disability-adjusted life years (DALYs), YLLs, and YLDs of OC were extracted from the online GBD database 2019. This year is the calendar year in which the most recent data for epidemiological indices are available at http://ghdx.healthdata.org. The GBD has estimated epidemiological indicators of 369 diseases and injuries for both sexes in 204 countries and territories based on various divisions of countries. For an accurate interpretation, we extracted OC data for 204 countries and for a variety of classifications based on the age groups, socio-demographic index (SDI), World Health Organization (WHO) regions, continents, World Bank regions, and GBD regions.[1] The SDI is a summary measure that identifies the position of countries or geographic areas on a scale of development from 0 (lowest) to 1 (highest). The SDI is the geometric mean of three factors including per capita income; average years of schooling, and total fertility rate (TFR).[2] The World Bank categorizes economies for analysis into four income groups: low, medium-low, medium-high, and high. It does this by using per capita gross national income (GNI) data in the United States dollars, converted into local currency using the World Bank's Atlas method, which applies to smooth changes in exchange rates.[3]

For GBD, an internationally standardized form of QALY has been developed, known as the adjusted year of life (DALY). DALY is defined as the years of life lost due to premature death and the years lived with a disability of specified severity and duration. A DALY is therefore a wasted year of healthy living. "Premature" death is defined as a death occurring before the age at which the dying person would have expected to survive if they were part of a standardized population with a life expectancy at birth equal to that of the longest surviving population in the world, Japan. For calculating the total number of DALYs for a given condition in a population, YLLs and years of disability of known severity and duration (YLDs) for this condition should be estimated and then added together.[9]

The data were reported as values at a 95% confidence interval (CI). ASRs were expressed in figures per 100,000 population to remove the influence of different ages in the patient population and to ensure comparability of statistical indicators. Definitions of the terminology used can be found at https://www.healthdata.org/terms-defined and https://www.healthdata.org/gbd/ (Figure 1).[9]

This study was approved by the ethics committee of the Birjand University of Medical Sciences (ethics committee approval code IR.BUMS.REC.1400.316). Because we routinely used anonymous electronic data, there was no need for patient consent.

3 | RESULTS

In 2019, a total of 294,422 new cases and 198,412 death due to ovarian cancer were reported. Most incidence cases, death cases, and burden number of ovarian cancer are observed in the age group of 50–69 years, but the highest crude rates is reserved for the age group above 70 years. The highest age-standardized incidence rate (ASIR) was reported in areas with higher SDI, World high-income countries, continental Europe, and then America. In GBD regions, the highest age-standardized incidence is in Central Europe. In 2019, a total of 198,412 deaths due to ovarian cancer were reported. The highest ASR death is related to countries with high SDI and the World Bank high-income countries. In 2019, adjusted years of life with DALYs due to ovarian cancer were reported to be 5,359,737, of which 5,205,660 were related to YLLs, and 154,077 were related to YLDs. More details have presented in the following.

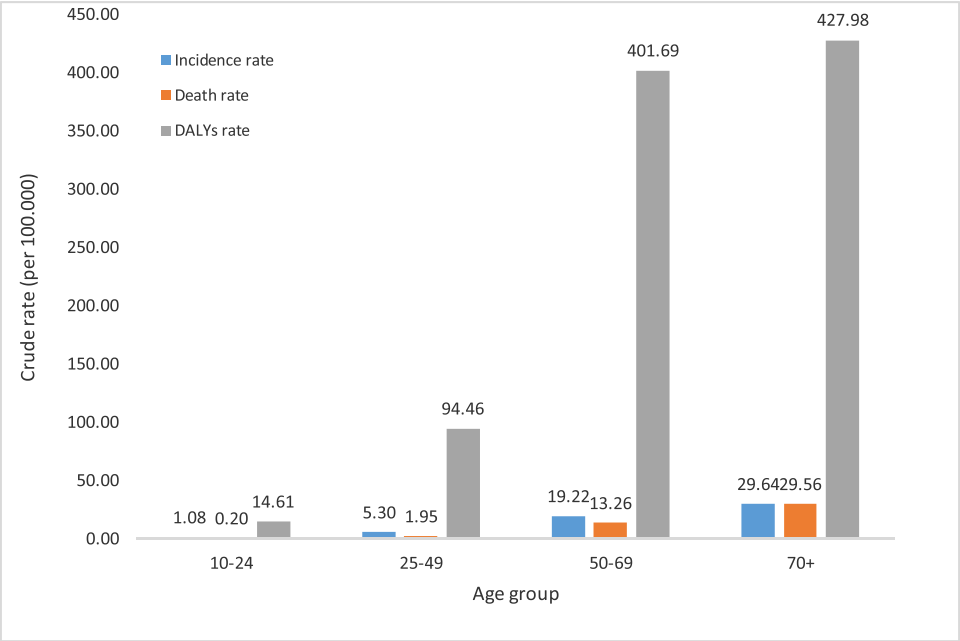

FIGURE 1 Global crude rate of incidence, death, and disabilities (DALYs) of ovarian cancer (per 100.000) in 2019. [Color figure can be viewed at wileyonlinelibrary.com]

3.1 | The global incidence rate of ovarian cancer

In 2019, a total of 294,422 new cases of ovarian cancer were reported with a 95% CI of (329,727–260,649) in women worldwide, with an ASR incidence of 6.87 per 100,000 people.

The highest standardized incidence rate of ovarian cancer per 100.0000 population was reported to be in Monaco (22.75), Brunei Darussalam (16.12), Pakistan (15.85), Seychelles (15.66), American Samoa (15.60), United States Virgin Islands (14.13), Greenland (13.57), United Kingdom (13.22), Samoa (13.12), and Ireland (12.84).

Also, the lowest standardized incidence rate of ovarian cancer per 100.0000 population was in Niger (2.15), Chad (2.25), Mali (2.50), Dominican Republic (2.53), Yemen (2.59), Central African Republic (2.66), Fiji (2.95), the Democratic Republic of the Congo (2.98), Sudan (3.07), and Egypt (3.27).

Most cases of ovarian cancer occure in the age group of 50–69 years, but the highest crude incidence rate is reserved for the age group above 70 years.

Statistics show that the higher the SDI index is, the higher the ASIR of ovarian cancer per 100.0000 population would be, and the highest age-standardized incidence of ovarian cancer is in countries with high SDI.

According to the World Bank classification, ASR incidence rate has the highest value (9.50) in the World Bank high-income countries and the lowest value in the World Bank low-income countries (4.88).

Among continents, the highest ASR incidence rate has been reported in continental Europe and then America, and the lowest has been observed in Africa.

Among the regions of the World Health Organization, the highest ASR incidence rate is related to Europe with 10.29 and the United States with 8.42, and the lowest value is related to the African Region with 4.94 per 100,000 people.

In GBD regions, the highest ASIR is in Central Europe (11.73) and the lowest is in Central Sub-Saharan Africa. More details was presented in Table 1.

3.2 | The global mortality rate of ovarian cancer

In 2019, a total of 198,412 deaths due to ovarian cancer were reported in women worldwide (95% CI: 175,357–217,665), with its ASR being equal to 4.56 (95% CI: 4.03–5.00). The highest standardized deaths from ovarian cancer have been reported in Monaco (13.67), Pakistan (11.84), Brunei Darussalam (10.08), American Samoa (10.00), United States Virgin Islands (9.84), Greenland (9.51), Latvia (9.22), Lithuania (9.09), Poland (9.05), and Seychelles (8.87).

The lowest standardized death rate from ovarian cancer has also been reported in the Dominican Republic (1.70), Niger (1.72), Chad (1.83), Fiji (1.93), Mali (1.93), Yemen (1.94), Sudan (2.18), Egypt (2.18), Central African Republic (2.24), and Syrian Arab Republic (2.29).

Most death cases of ovarian cancer are observed in the age group of 50–69 years, but the highest crude death rate is reserved for the age group above 70 years.

The highest ASR death is related to countries with high SDI so, in high SDI countries, the value of ASR death is 5.67. Also, the lowest ASR death is related to medium SDI level countries (3.66) and low SDI level countries (4.01).

According to the World Bank classification, the highest ASR death belongs to the World Bank high-income countries.

TABLE 1 Ovarian cancer incidence cases, age-standardized incidence rate, death cases, age-standardized mortality rate, disabilities (DALYs) number, age-standardized DALY rates, years of life (YLLs) number, age-standardized YLLs rates, years of life with disabilities (YLDs) number, and age-standardized YLDs rates in 2019

	Incidence cases (95% confidence interval [CI])	Incidence ASR per 10^5 (95% CI)	Deaths cases (95% CI)	Deaths ASR per 10^5 (95% CI)	DALYs number (95% CI)	DALYs ASR per 10^5 (95% CI)	YLLs number (95% CI)	YLLs ASR per 10^5 (95% CI)	YLDs number (95% CI)	YLDs ASR per 10^5 (95% CI)
Global	**294,422**	**6.87**	**198,412**	**4.56**	**5,359,737**	**124.68**	**5,205,660**	**121.08**	**154,077**	**3.60**
	(260,649–329,727)	(6.08–7.7)	(175,357–217,665)	(4.03–5)	(4,692,949–5,954,993)	(109.13–138.67)	(4,579,409–5,768,211)	(106.41–134.29)	(111,432–199,195)	(2.6–4.66)
Age (year)[a]										
10–24	**9791**	**1.08**	**1831**	**0.20**	**132,702**	**14.61**	**127,863**	**14.08**	**4839**	**0.53**
	(8157–11,315)	(0.90–1.25)	(1502–2140)	(0.17–0.24)	(108,964–154,412)	(132.56–154.51)	(105,208–149,572)	(11.58–16.47)	(3220–6721)	(0.35–0.74)
25–49	**71,404**	**5.30**	**26,265**	**1.95**	**1,273,093**	**94.46**	**1,230,189**	**91.27**	**42,904**	**3.18**
	(61,669–81,455)	(4.58–6.04)	(22,648–29,966)	(1.68–2.22)	(1,094,179–1,453,982)	(114.83–147.47)	(1,056,915–1,406,380)	(78.42–104.34)	(30,409–56,214)	(2.26–4.17)
50–69	**135,107**	**19.22**	**93,173**	**13.26**	**2,823,174**	**401.69**	**2,749,353**	**391.18**	**73,821**	**10.50**
	(118,168–151,221)	(16.81–21.52)	(81,327–103,381)	(11.57–14.71)	(2,459,433–3,132,271)	(349.93–445.67)	(2,408,510–3,056,934)	(342.69–434.95)	(53,545–95,838)	(7.62–13.64)
70+	**77,131**	**29.64**	**76,943**	**29.56**	**1,113,871**	**427.98**	**1,081,826**	**415.67**	**23,045**	**12.31**
	(66,946–85,958)	(25.72–33.03)	(66,525–84,280)	(25.56–32.38)	(975,511–1,221,853)	(374.82–469.47)	(946,404–1,183,387)	(363.64–454.69)	(22,814–41,606)	(8.77–15.99)
Socio-demographic index (SDI)										
High SDI	**80,454**	**9.30**	**56,639**	**5.67**	**1,229,123**	**143.78**	**1,186,172**	**138.58**	**42,952**	**5.21**
	(70,504–91,461)	(8.23–10.56)	(50,391–61,318)	(5.16–6.09)	(1,125,703–1,323,417)	(132.56–154.51)	(1,088,737–1,276,255)	(128.26–149.15)	(30,604–56,621)	(3.71–6.88)
High-middle SDI	**77,286**	**7.56**	**51,967**	**4.75**	**1,378,231**	**133.03**	**1,337,300**	**128.98**	**40,931**	**4.06**
	(65,885–86,459)	(6.43–8.45)	(44,998–57,246)	(4.11–5.24)	(1,191,048–1,526,401)	(114.83–147.47)	(1,154,016–1,480,447)	(111.43–142.89)	(29,187–53,714)	(2.9–5.33)
Middle SDI	**76,545**	**5.71**	**48,485**	**3.66**	**1,453,634**	**106.38**	**1,413,034**	**103.39**	**40,599**	**2.99**
	(63,249–88,974)	(4.7–6.63)	(39,894–56,526)	(3.01–4.26)	(1,199,319–1,696,724)	(87.67–123.96)	(1,163,156–1,651,798)	(85.21–120.85)	(28,081–54,222)	(2.08–3.99)
Low-middle SDI	**43,595**	**5.65**	**29,874**	**4.09**	**922,653**	**118.41**	**901,082**	**115.66**	**21,572**	**2.75**
	(35,303–54,683)	(4.6–7.08)	(24,421–37,624)	(3.36–5.15)	(740,013–1,169,375)	(95.38–150.23)	(72,1249–1,144,629)	(93.14–146.56)	(14,904–29,906)	(1.9–3.8)
Low SDI	**16,389**	**5.15**	**11,346**	**4.01**	**373,324**	**115.17**	**365,380**	**112.75**	**7943**	**2.42**
	(13,486–20,299)	(4.28–6.34)	(9551–13,928)	(3.38–4.88)	(311,090–462,226)	(96.36–141.83)	(303,521–453,302)	(94.11–139.39)	(5519–10,942)	(1.7–3.31)
World bank income level										
High income	**98,039**	**9.50**	**69,467**	**5.79**	**1,510,884**	**148.00**	**1,458,756**	**142.69**	**52,128**	**5.30**
	(86,477–111,022)	(8.42–10.77)	(61,668–75,181)	(5.27–6.23)	(1,390,475–1,628,908)	(136.96–159.78)	(1,342,419–1,570,417)	(132.28–154.1)	(37,358–68,078)	(3.8–6.95)

TABLE 1 (Continued)

	Incidence cases (95% confidence interval [CI])	Incidence ASR per 10^5 (95% CI)	Deaths cases (95% CI)	Deaths ASR per 10^5 (95% CI)	DALYs number (95% CI)	DALYs ASR per 10^5 (95% CI)	YLLs number (95% CI)	YLLs ASR per 10^5 (95% CI)	YLDs number (95% CI)	YLDs ASR per 10^5 (95% CI)
Upper middle income	**101,597** (85,089–116,382)	**5.87** (4.92–6.72)	**66,258** (55,420–75,367)	**3.69** (3.09–4.2)	**1,881,410** (1,573,261–2,142,081)	**106.39** (89.13–120.94)	**1,827,273** (1,528,614–2,086,965)	**103.27** (86.55–117.84)	**54,137** (38,022–72,221)	**3.13** (2.19–4.17)
Lower middle income	**84,862** (68,602–103,948)	**6.25** (5.09–7.64)	**55,844** (44,897–69,102)	**4.39** (3.56–5.4)	**1,744,032** (1,379,802–2,164,085)	**127.17** (100.99–157.55)	**1,701,093** (1,346,144–2,117,388)	**124.07** (98.64–154.16)	**42,939** (29,188–59,162)	**3.10** (2.12–4.28)
Low income	**9771** (7806–13,296)	**4.88** (3.96–6.58)	**6742** (5475–8987)	**3.78** (3.09–4.95)	**220,627** (175,376–301,015)	**108.44** (87.23–145.67)	**215,834** (172,054–293,370)	**106.11** (85.4–142.4)	**4793** (3194–7071)	**2.33** (1.57–3.37)
Continents										
Africa	**19,102** (16,002–23,327)	**4.88** (4.1–5.91)	**13,042** (10,957–15,734)	**3.77** (3.18–4.51)	**420,490** (350,218–508,652)	**105.39** (88.59–127.26)	**410,993** (342,635–498,067)	**103.05** (86.68–124.21)	**9497** (6537–13,085)	**2.34** (1.62–3.19)
America	**54,660** (48,037–62,718)	**8.42** (7.4–9.68)	**37,960** (34,793–41,354)	**5.54** (5.1–6.03)	**941,223** (872,363–1,025,609)	**145.34** (135.01–158.52)	**913,110** (848,894–994,433)	**140.94** (130.82–153.63)	**28,113** (20,462–37,045)	**4.40** (3.18–5.8)
Asia	**144,017** (117,220–168,876)	**5.73** (4.66–6.7)	**92,385** (76,661–108,030)	**3.67** (3.05–4.3)	**2,730,014** (2,239,232–3,219,963)	**107.20** (88.04–126.71)	**2,653,514** (2,168,511–3,133,614)	**104.18** (85.24–122.93)	**76,500** (53,880–101,950)	**3.02** (2.13–4.03)
Europe	**76,246** (67,263–86,107)	**10.45** (9.26–11.81)	**54,747** (49,071–59,501)	**6.54** (5.86–7.09)	**1,261,096** (1,133,260–1,374,872)	**173.73** (155.91–189.36)	**1,221,335** (1,098,843–1,327,233)	**168.04** (150.53–183.41)	**39,761** (28,544–51,874)	**5.69** (4.06–7.47)
WHO regions										
African region	**15,412** (12,765–18,662)	**4.94** (4.1–5.9)	**10,710** (8854–12,748)	**3.89** (3.21–4.6)	**345,283** (283,387–419,122)	**108.44** (89.51–130.43)	**337,722** (277,835–410,785)	**106.10** (87.62–127.06)	**7561** (5188–10,534)	**2.34** (1.62–3.21)
Eastern Mediterranean region	**19,838** (13,825–26,991)	**7.81** (5.56–10.58)	**12,381** (8675–17,228)	**5.53** (3.91–7.77)	**417,061** (283,568–581,659)	**161.78** (111.88–225.03)	**407,000** (276,999–568,923)	**157.95** (109.21–220.4)	**10,061** (6132–15,232)	**3.82** (2.35–5.68)
European region	**79,091** (69,855–89,199)	**10.29** (9.12–11.62)	**56,568** (50,623–61,385)	**6.48** (5.82–7.03)	**1,316,591** (1,184,739–1,432,571)	**172.42** (154.65–187.99)	**1,275,334** (1,147,190–1,384,512)	**166.84** (149.43–181.53)	**41,256** (29,588–54,003)	**5.59** (3.98–7.34)
Region of the Americas	**54,660** (48,037–62,718)	**8.42** (7.4–9.68)	**37,960** (34,793–41,354)	**5.54** (5.1–6.03)	**941,223** (872,363–1,025,609)	**145.34** (135.01–158.52)	**913,110** (848,894–994,433)	**140.94** (130.82–153.63)	**28,113** (20,462–37,045)	**4.40** (3.18–5.8)
South-East Asia region	**53,078** (42,733–66,649)	**5.60** (4.52–7)	**35,637** (28,489–44,890)	**3.94** (3.16–4.94)	**1,076,925** (857,775–1,360,596)	**112.16** (89.63–141.58)	**1,050,130** (835,674–1,327,693)	**109.38** (87.01–138.65)	**26,795** (18,174–37,097)	**2.77** (1.89–3.83)

(Continues)

TABLE 1 (Continued)

	Incidence cases (95% confidence interval [CI])	Incidence ASR per 10^5 (95% CI)	Deaths cases (95% CI)	Deaths ASR per 10^5 (95% CI)	DALYs number (95% CI)	DALYs ASR per 10^5 (95% CI)	YLLs number (95% CI)	YLLs ASR per 10^5 (95% CI)	YLDs number (95% CI)	YLDs ASR per 10^5 (95% CI)
Western pacific region	**71,560** (56,926–84,580)	**5.38** (4.3–6.34)	**44,592** (35,091–52,688)	**3.16** (2.5–3.72)	**1,247,835** (992,129–1,478,321)	**91.65** (73.38–108.82)	**1,207,944** (957,189–1,437,491)	**88.65** (70.68–105.85)	**39,892** (27,454–54,420)	**3.00** (2.06–4.1)
Global burden of disease (GBD) region										
East Asia and Pacific —WB	**89,150** (72,208–105,913)	**5.73** (4.64–6.83)	**54,896** (44,103–65,169)	**3.36** (2.7–3.99)	**1,576,687** (1,271,686–1,884,770)	**99.09** (79.82–118.32)	**1,527,282** (1,225,534–1,827,548)	**95.92** (76.98–114.66)	**49,406** (33,970–66,390)	**3.17** (2.17–4.28)
East Asia	**47,852** (35,082–59,600)	**4.61** (3.41–5.74)	**30,350** (22,124–38,066)	**2.79** (2.05–3.49)	**871,645** (645,106–1,098,317)	**81.21** (60.66–102.31)	**845,223** (623,738–1,074,725)	**78.67** (58.71–99.72)	**26,422** (17,140–36,843)	**2.54** (1.65–3.55)
Oceania	**184** (121–362)	**4.25** (2.89–8.03)	**110** (74–209)	**2.94** (2.05–5.34)	**3792** (2478–7547)	**85.48** (57.56–163.77)	**3692** (2411–7330)	**83.26** (56.06–159.74)	**100** (55–189)	**2.22** (1.26–4.11)
Southeast Asia	**28,151** (21,777–38,998)	**7.98** (6.19–11.04)	**16,187** (12,722–22,681)	**4.76** (3.75–6.64)	**517,385** (404,021–726,116)	**144.22** (112.72–201.78)	**502,073** (3,91,587–708,907)	**139.95** (109.1–196.97)	**15,311** (10,211–22,155)	**4.27** (2.83–6.2)
Sub-Saharan Africa —WB	**15,173** (12,576–18,390)	**4.93** (4.08–5.85)	**10,591** (8763–12,607)	**3.91** (3.25–4.62)	**342,481** (281,688–413,898)	**108.76** (89.99–130.07)	**335,068** (275,835–405,454)	**106.44** (88.08–127.06)	**7413** (5080–10,249)	**2.32** (1.6–3.18)
Central Sub-Saharan Africa	**1120** (728–1809)	**3.20** (2.1–5.13)	**800** (522–1299)	**2.59** (1.67–4.11)	**26,272** (17,015–43,122)	**72.61** (47.24–118.81)	**25,713** (16,603–42,114)	**71.06** (46.32–115.96)	**559** (312–978)	**1.55** (0.86–2.67)
Eastern Sub-Saharan Africa	**6349** (5046–7696)	**6.00** (4.86–7.18)	**4456** (3629–5408)	**4.83** (3.95–5.78)	**147,571** (117,400–181,455)	**136.91** (110.38–166.46)	**144,510** (115,657–177,728)	**134.13** (108.71–163.46)	**3060** (2044–4259)	**2.78** (1.91–3.79)
Southern Sub-Saharan Africa	**2323** (1903–2786)	**6.70** (5.5–7.97)	**1687** (1380–2011)	**5.14** (4.21–6.11)	**48,660** (39,766–58,352)	**138.52** (113.33–166.72)	**47,548** (38,769–57,370)	**135.38** (110.84–163.5)	**1112** (753–1510)	**3.14** (2.13–4.23)
Western Sub-Saharan Africa	**4961** (3595–6761)	**4.06** (2.87–5.53)	**3406** (2427–4570)	**3.19** (2.24–4.24)	**111,798** (80,399–150,518)	**89.45** (63.79–120.33)	**109,345** (78,649–147,383)	**87.51** (62.46–117.87)	**2453** (1526–3681)	**1.93** (1.19–2.88)
South Asia — WB	**46,894** (35,926–57,882)	**5.89** (4.56–7.21)	**32,782** (25,477–40,563)	**4.36** (3.4–5.42)	**1,003,594** (769,827–1,260,272)	**124.29** (95.82–155.48)	**980,809** (748,881–1,233,016)	**121.49** (93.63–151.79)	**22,785** (15,211–31,890)	**2.80** (1.87–3.93)
South Asia	**45,756** (34,899–56,554)	**5.91** (4.58–7.29)	**32,105** (24,894–39,896)	**4.40** (3.39–5.48)	**982,473** (748,576–1,238,008)	**125.29** (95.91–157.33)	**960,310** (731,208–1,213,466)	**122.49** (93.83–154.25)	**22,162** (14,598–31,253)	**2.80** (1.85–3.96)

TABLE 1 (Continued)

	Incidence cases (95% confidence interval [CI])	Incidence ASR per 10^5 (95% CI)	Deaths cases (95% CI)	Deaths ASR per 10^5 (95% CI)	DALYs number (95% CI)	DALYs ASR per 10^5 (95% CI)	YLLs number (95% CI)	YLLs ASR per 10^5 (95% CI)	YLDs number (95% CI)	YLDs ASR per 10^5 (95% CI)
Latin America and Caribbean—WB	**25,106** (21,973–28,857)	**6.97** (6.1–8.01)	**16,499** (14,784–18,370)	**4.56** (4.08–5.07)	**472,156** (421,359–527,376)	**130.42** (116.31–145.77)	**459,261** (410,007–512,364)	**126.85** (113.21–141.51)	**12,895** (9055–17,224)	**3.57** (2.51–4.77)
Andean Latin America	**2153** (1522–2768)	**7.05** (4.98–9.04)	**1370** (968–1735)	**4.63** (3.28–5.86)	**40,930** (29,298–52,538)	**134.17** (95.92–171.71)	**39,833** (28,267–51,060)	**130.60** (92.74–167)	**1097** (689–1580)	**3.56** (2.24–5.12)
Caribbean	**1527** (1102–2044)	**5.72** (4.15–7.7)	**1039** (734–1396)	**3.81** (2.7–5.14)	**29,259** (21,130–40,851)	**109.44** (78.94–153.64)	**28,472** (20,460–40,045)	**106.48** (76.66–150.59)	**788** (488–1145)	**2.96** (1.84–4.33)
Central Latin America	**9795** (8127–11,851)	**7.46** (6.2–9.03)	**6141** (5096–7294)	**4.76** (3.95–5.65)	**183,814** (152,067–220,400)	**139.44** (115.36–167.07)	**178,738** (147,666–213,922)	**135.60** (112.25–162.42)	**5076** (3457–6935)	**3.84** (2.62–5.24)
Tropical Latin America	**8058** (7382–8806)	**6.13** (5.61–6.7)	**5436** (4963–5914)	**4.09** (3.73–4.45)	**153,726** (140,925–167,334)	**115.92** (106.16–126.13)	**149,611** (137,010–163,047)	**112.79** (103.21–122.95)	**4116** (2972–5394)	**3.12** (2.27–4.09)
Middle East and North Africa—WB	**9647** (7690–11,704)	**5.26** (4.24–6.42)	**5748** (4694–7086)	**3.50** (2.88–4.35)	**181,725** (144,816–220,246)	**98.10** (79.37–120.27)	**176,514** (141,299–213,984)	**95.35** (77.13–116.59)	**5211** (3510–7141)	**2.75** (1.88–3.76)
North Africa and Middle East	**12,877** (10,395–15,071)	**5.27** (4.29–6.15)	**7825** (6488–9137)	**3.54** (2.93–4.17)	**243,815** (198,307–284,283)	**98.96** (80.8–115.45)	**236,913** (192,597–27,6861)	**96.22** (78.8–112.34)	**6902** (4807–9251)	**2.74** (1.92–3.67)
Europe and Central Asia—WB	**78,344** (69,145–88,268)	**10.30** (9.13–11.62)	**56,049** (50,133–60,851)	**6.49** (5.82–7.03)	**1,304,179** (1,173,342–1,419,380)	**172.53** (154.69–188.33)	**1,263,316** (1,135,966–1,373,223)	**166.93** (149.38–181.85)	**40,863** (29,330–53,499)	**5.59** (3.98–7.34)
Central Asia	**3187** (2759–3567)	**6.94** (6–7.76)	**2044** (1768–2287)	**4.68** (4.04–5.22)	**64,750** (56,175–72,871)	**138.41** (119.88–155.6)	**63,090** (54,830–71,029)	**134.87** (117.06–151.4)	**1660** (1175–2246)	**3.54** (2.5–4.79)
Central Europe	**11,713** (9997–13,583)	**11.73** (9.96–13.69)	**8650** (7446–10,044)	**7.64** (6.57–8.88)	**210,935** (181,004–245,579)	**212.29** (181.69–247.19)	**204,967** (175,787–238,504)	**206.05** (176.37–240.47)	**5968** (4129–7958)	**6.23** (4.34–8.41)
Eastern Europe	**18,954** (15,904–22,903)	**10.84** (9.01–13.11)	**13,285** (11,081–15,918)	**6.74** (5.61–8.05)	**360,688** (299,272–431,833)	**202.71** (167.41–242.93)	**350,986** (290,716–419,913)	**196.97** (162.35–236.55)	**9702** (6596–13,099)	**5.74** (3.87–7.84)
High income	**89,464** (78,273–102,114)	**9.35** (8.23–10.73)	**63,521** (56,655–68,732)	**5.67** (5.16–6.11)	**1,362,224** (1,251,359–1,464,605)	**144.04** (133.76–154.83)	**1,314,635** (1,211,446–1,411,257)	**138.80** (128.4–148.95)	**47,589** (33,847–62,199)	**5.24** (3.75–6.87)

(Continues)

TABLE 1 (Continued)

	Incidence cases (95% confidence interval [CI])	Incidence ASR per 10^5 (95% CI)	Deaths cases (95% CI)	Deaths ASR per 10^5 (95% CI)	DALYs number (95% CI)	DALYs ASR per 10^5 (95% CI)	YLLs number (95% CI)	YLLs ASR per 10^5 (95% CI)	YLDs number (95% CI)	YLDs ASR per 10^5 (95% CI)
Australasia	**1931** (1524–2472)	**8.24** (6.52–10.64)	**1384** (1182–1592)	**5.29** (4.58–6.1)	**29,637** (25,738–34,301)	**128.09** (111.45–149.4)	**28,622** (24,903–33,016)	**123.59** (107.33–143.7)	**1015** (665–1481)	**4.49** (2.97–6.67)
Asia Pacific	**11,882** (9655–14,073)	**6.85** (5.55–8.16)	**7341** (6205–8064)	**3.45** (3.03–3.72)	**167,714** (147,322–181,069)	**101.18** (89.47–107.95)	**16,072** (141,691–172,749)	**96.98** (86–103.22)	**7042** (4823–9558)	**4.20** (2.88–5.8)
North America	**29,785** (24,355–36,248)	**9.85** (7.96–12.05)	**21,631** (19,536–23,591)	**6.41** (5.85–6.95)	**472,990** (439,017–512,580)	**156.34** (145.58–170.22)	**457,654** (424,624–497,875)	**151.06** (140.83–164.41)	**15,336** (10,653–20,823)	**5.28** (3.68–7.19)
Southern Latin America	**3631** (2833–4644)	**8.53** (6.61–10.9)	**2553** (2344–2877)	**5.64** (5.19–6.35)	**65,518** (60,158–73,658)	**154.93** (142.56–173.7)	**63,670** (58,671–71,159)	**150.51** (138.73–168.3)	**1848** (1180–2666)	**4.42** (2.81–6.41)
Western Europe	**42,235** (36,189–49,048)	**10.38** (8.98–12.1)	**30,612** (27,024–33,277)	**6.28** (5.7–6.76)	**626,364** (569,657–678,617)	**154.84** (142.25–167.85)	**604,016** (552,397–651,502)	**148.99** (136.83–161.39)	**22,348** (15,499–29,649)	**5.85** (4.08–7.8)

[a]Rates for age groups are crude rate.

Among the continents, the highest number of ASR deaths have been reported in continental Europe followed by America, and have lowest has been reported in Africa.

According to the World Health Organization, the highest ASR death rate belongs to the European Region, followed by the American region, and the lowest belongs to the Western Pacific Region.

Also based on GBD regions, the highest ASR death rate is in Central Europe and the lowest is in Central Sub-Saharan Africa. More details was presented in Table 1.

3.3 | The global burden of ovarian cancer

In 2019, DALYs number due to ovarian cancer were reported to be 5,359,737 (95% CI: 4,692,949–5,954,993), of which 5,205,660 (95% CI: 4,579,409–5,768,211) were related to YLLs cases and 154,077 (95% CI: 111,432–199,195) were related to YLDs cases. The DALYs ASR for women with ovarian cancer was reported to be 124.68 per 100.000 worldwide, and the value for YLLs ASR and YLDs ASR was 121.08 and 3.60 per 100,000, respectively.

The highest DALYs ASR have been reported in Pakistan (348.37), Monaco (342.07), Brunei Darussalam (9281.99), American Samoa (278.73), Seychelles (263.45), United States Virgin Islands (262.27), Greenland (258.85), Latvia (256.61), Lithuania (255.91), and Guyana (247.63).

The lowest ASR DALYs have been observed in Niger (49.54), Dominican Republic (50.30), Chad (52.55), Yemen (56.53), Fiji (56.99), Mali (57.64), Sudan (63.40), Central African Republic (64.30), Egypt (64.79), and Syrian Arab Republic (66.46).

The highest YLDs ASR have been also reported in Monaco (12.63), Brunei Darussalam (8.63), Seychelles (8.57), American Samoa (8.04), Croatia (7.71), United Kingdom (7.38), Pakistan (7.33), Ireland (7.15), United States Virgin Islands (7.12), and Czechia (7.02). Meanwhile, the lowest YLDs ASR have been observed in Niger (1.06), Chad (1.1), Mali (1.25), Central African Republic (1.27), Yemen (1.34), Dominican Republic (1.36), Democratic Republic of the Congo (1.46), Angola (1.57), Burkina Faso (1.6), and Benin (1.6).

The highest YLLs ASR have been reported in Pakistan (341.04), Monaco (329.45), Brunei Darussalam (273.35), American Samoa (270.69), United States Virgin Islands (255.14), Seychelles (254.87), Greenland (252.07), Latvia (250.89), Lithuania (249.90), and Guyana (241.86). Meanwhile, the lowest YLLs ASR have been reported in Niger (48.48), Dominican Republic (48.94), Chad (51.45), Yemen (55.19), Fiji (55.34), Mali (56.39), Sudan (61.79), Central African Republic (63.03), Egypt (63.05), and Syrian Arab Republic (64.54).

Most burden number of ovarian cancer are observed in the age group of 50–69 years, but the highest crude burden rate is reserved for the age group above 70 years.

According to the SDI classification, the highest DALYs ASR belong to the high SDI countries, and the lowest DALYs ASR belongs to the medium-low SDI countries. High SDI countries also have the highest values of YLLs and YLDs.

In terms of World Bank classification, the highest DALYs ASR and YLLs ASR belong to the World Bank high-income and lower-middle-income countries, respectively. The highest ASR YLDs belong to the World Bank high-income countries and the lowest ASR YLDs belong to the World Bank low-income countries.

On different continents, the highest DALYs ASR values belong to Europe and then American continents. Regarding YLLs ASR and YLDs ASR, the highest value is related to continental Europe and the lowest value is related to Africa.

According to WHO regions, the highest DALYs ASR and YLLs ASR have been reported in the European Region, followed by the Eastern Mediterranean Region, while the lowest DALYs ASR and YLLs ASR have been reported in the Western Pacific Region. Regarding YLDs ASR, the highest value belongs to the European Region and the lowest value belongs to the African Region.

Regarding the GBD regions, the highest DALYs ASR, YLLs ASR, and YLDs ASR of ovarian cancer have been reported in Central Europe and the lowest have been reported in Central Sub-Saharan Africa.

More details was presented in Table 1.

4 | DISCUSSION

According to the results of this study, in 2019, a total of 294,422 cases of ovarian cancer occurred in the world and 19,841,212 deaths were recorded due to this cancer. Ovarian cancer caused 5,359,737 DALYs worldwide, of which 5,205,660 were from YLLs and 154,077 were from YLDs. Also, incidence and mortality rates of ovarian cancer vary according to SDI, with the highest rates occurring in high SDI countries.

Compared to the results of GBD 2017, the incidence of this cancer has been increasing,[10] which is associated with various factors such as changes in the risk factors, improved disease registration, and lifestyle changes. About 50% of ovarian cancers occur in high SDI countries, and a significant proportion of DALYs/YLLs belong to these countries. However, the share of low SDI countries in this disease is also significant. Analysis of statistics shows that to achieve and guarantee sustainable development, identifying and eliminating health inequalities has a high priority because when access to cancer care increases and medical treatment improves, the mortality rate decreases.[11]

According to GBD results, the incidence, mortality, and DALYs associated with ovarian cancer have been increasing from 1990 to 2019, and this increase has been greater in recent decades. Although changes in ASIR, ASDR, and age-standardized DALY rates are generally not significant, they show a significant decrease in high SDI areas. This trend has been slowly increasing in the medium-low SDI and low SDI regions.[12] ASIR, ASDR, and age-standardized DALY rates are positively correlated with SDI. However, when the SDI value is greater than 0.7, ASIR, ASDR, and the age-standardized DALY rate decrease rapidly with increasing SDI.[13]

Ovarian cancer is more common in postmenopausal women and the European and Western Pacific regions than in Africa and the Eastern Mediterranean Region.[13] Some of these statistical differences can be justified by considering the risk factors associated with this disease.

The use of oral contraceptives (OC) is associated with a reduction in all histological types of ovarian cancer.[14,15] The results of a study showed a reduction in ovarian cancer in cohorts born in the 1920s in Australia and the United States, which could be due to the onset of OC use in the 1960s.[16] In addition, the decline in cancer-related statistics is greater in countries where OC use has a long history and is more widely used. Reducing the use of OC and other methods of contraception as well as changing the formulation of OC may change the trend of ovarian cancer in recent years. In addition to OC, the use of menopausal hormone therapy is also related to the risk of ovarian cancer. In this regard, the result of a study showed the successful experience of US in reducing the rate of ovarian cancer after a marked reduction in the use of menopausal hormone therapy.[17]

The results of studies show that pregnancy plays a protective role against ovarian cancer.[18–20] A history of a full-term pregnancy or multiple deliveries are associated with a reduction in the incidence of ovarian cancer in individuals.[2] Therefore, an increase in the rate of ovarian cancer in some countries may be due to a decrease in the tendency of women to conceive in these areas. Adaptation to the western lifestyle in some areas is associated with changes in ovarian cancer rate.[21] In this regard, the result of s study reported a gradual increase in the ASR of ovarian cancer until 2012 in China (Shanghai), Spain (Navarra) and Slovakia, which was closely related to the decline in the TFR during the same period.[22]

There is an inverse relationship between the duration of breastfeeding, the number of breastfed children, and the risk of ovarian cancer.[23] Studies show that promoting breastfeeding, in addition to its benefits for the infant, is associated with a reduction in ovarian cancer cases.[2] Due to the increase of working women and the introduction and promotion of powdered milk around 1970, the rate of breastfeeding among mothers born between 1935 and 1939 decreased to 44 percent. By 1975, the proportion of mothers who were breastfeeding began to increase, and between 70% and 75% of mothers born in 1960 or later were breastfeeding their children. This evidence made breastfeeding to be included in the list of successful experiences of countries to reduce the incidence of ovarian cancer[24] Today, in countries where breastfeeding is more common, ovarian cancer is expected to be less.[25]

Obesity is associated with an increased risk of ovarian cancer, decreased survival rate, and increased mortality.[26] The current lifestyle and the increase in obesity in recent years have played a role in increasing the incidence of ovarian cancer.[27] Theoretically, red meat is associated with an increased risk of ovarian cancer as it contains several mutagens such as carcinogenic heterocyclic amines, endogenous formation of nitroso compounds, fat, salt, and iron.[28] According to the study by Micha, the lowest consumption of meat has been reported in South Asia (7.3 g/day), Southeast Asia

(26.0 g/day), West Sub-Saharan Africa (33.0 g/day), East Sub-Saharan Africa (34.1 g/day), and Caribbean (34.4 g/day).[29] On the other hand, the consumption of vegetables, vitamin supplements, beta-carotene, and B-complex vitamins has been shown to reduce the risk of ovarian cancer.[30] Therefore, diet modification should be considered one of the priorities.

Since ovarian epithelial cancer is an age-related disease and is more common in postmenopausal women,[30,31] increasing population age in some areas has led to higher rates of ovarian cancer in these areas.[32] In addition, older age is associated with more severe diseases and a lower survival rate.[33]

Part of the increase in ovarian cancer-related mortality can be justified by inequalities in disease-related care and treatment protocols as well as the standards of these protocols, although genetic susceptibility, comorbidity, and increased risk factors also play a role in this regard.[34,35] The use of modern diagnosis and treatment methods for ovarian cancer can reduce its mortality rate, although not enough data are available to compare different parts of the world in this regard.[35] However, it seems that this factor can explain part of the ovarian cancer mortality rate. On the other hand, differences in the treatment of ovarian cancer, followed by differences in survival rates among people with equal access to care can also be observed. Therefore, biological, individual, and social factors are involved in the variation of ovarian cancer mortality and survival rates.

Designing interventions based on risk factors as well as providing preventive approaches to reduce the risk of this cancer is recommended. Improving the treatment of ovarian cancer and using appropriate and invasive treatments should also be considered. It seems that the use of preventive methods and appropriate treatment can play a role in reducing ovarian cancer cases.

This study had limitations that are mentioned below. First, although the data were collected from various sources, the data from some regions is limited, which could affect the results of the present study. In addition, the data are based on a variety of data sources, such as cancer registry data and cytological results, while access to these sources is limited in some low-income countries, and statistical estimates may be inaccurate.

AUTHOR CONTRIBUTIONS

Afrooz Mazidimoradi: Conceptualization; data curation; formal analysis; funding acquisition; methodology; software; validation; writing – original draft; writing – review and editing. **Zohre Momenimovahed**: Conceptualization; data curation; funding acquisition; project administration; supervision; writing – original draft; writing – review and editing. **Leila Allahqoli**: Conceptualization; data curation; formal analysis; methodology; supervision; writing – original draft; writing – review and editing. **Azita Tiznobaik**: Conceptualization; data curation; investigation; writing – original draft; writing – review and editing. **Negar Hajinasab**: Conceptualization; data curation; investigation; software; writing – original draft; writing – review and editing. **Hamid Salehiniya**: Conceptualization; data curation; investigation; project administration; resources; supervision; writing – original draft; writing – review and editing. **Ibrahim Alkatout**: Conceptualization; investigation; project administration; supervision; validation; writing – original draft; writing – review and editing.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data presented in this study are available on request from the corresponding author.

ETHICS STATEMENT

The study was approved by the ethics committee of the Birjand University of Medical Sciences (ethics committee approval code IR.BUMS.REC.1400.316). As we used routinely collected anonymized electronic data, patient consent was not required. All procedures were performed in accordance with the relevant guidelines and regulations.

TRANSPARENCY STATEMENT

The lead author Hamid Salehiniya affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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