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Original Research

Time Trends in Unilateral and Bilateral Oophorectomy in a Geographically Defined American Population

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OBJECTIVE: To evaluate trends in the incidence of premenopausal unilateral and bilateral oophorectomy between 1950 and 2018.

METHODS: The Rochester Epidemiology Project medical records–linkage system was used to identify all women aged 18–49 years who were residents of Olmsted County, Minnesota, and underwent unilateral or bilateral oophorectomy before spontaneous menopause between January 1, 1950, and December 31, 2018. Population denominators were derived from the U.S. Decennial Censuses for the years 1950–2010, and intercensal year population denominators were linearly interpolated. For 2011–2018, the annual population denominators were obtained from the U.S. Census projections. Where appropriate, overall incidence rates were age-adjusted to the total U.S. female population from the 2010 Census.

See related editorial on page 721.

RESULTS: There were 5,154 oophorectomies in Olmsted County across the 69-year period between 1950 and 2018, and 2.9% showed malignant disease on pathology. A total of 2,092 (40.6%) women underwent unilateral oophorectomy, and 3,062 (59.4%) women underwent bilateral oophorectomy. More than half (n=1,750, 57.2%) of the bilateral oophorectomies occurred between 1990 and 2009. Until 1975–1979, the incidence of unilateral oophorectomy was mostly higher than bilateral oophorectomy. From 1980–1984 until 2000–2004, the incidence of bilateral oophorectomy more than doubled and the incidence of unilateral oophorectomy declined. After 2005, both procedures declined and converged to a similar incidence in 2015–2018. The decline in premenopausal bilateral oophorectomy over the past 14 years (2005–2018) was most pronounced for women who underwent oophorectomy concurrently with hysterectomy or did not have any ovarian indication.

CONCLUSION: The incidence rates of unilateral and bilateral oophorectomy have varied greatly across the 69-year period of this study. In the past 14 years, the

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incidence of premenopausal unilateral and bilateral oophorectomy has decreased. These trends reflect the effects of the initial 2005–2006 publications and the subsequent expanding body of evidence against the practice of oophorectomy for noncancer indications.
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Hysterectomy is one of the most commonly performed surgical procedures for women in the United States[1,2]; only 8% of hysterectomies are performed for malignancies of the reproductive tract.[3,4] At the time of hysterectomy, an estimated 23% of women aged 40–44 years and 45% of women aged 45–49 years concurrently undergo bilateral oophorectomy for the prevention of ovarian cancer, even among women who are at average risk.[5,6] Historically, the ovaries were not considered an endocrine organ and, thus, were not seen as a necessity beyond reproduction.[7–9] However, the removal of both ovaries before spontaneous menopause causes abrupt endocrine dysfunction, with immediate cessation of ovarian production of estrogen, progesterone, and testosterone and an abrupt increase of gonadotropins (luteinizing hormone and follicle-stimulating hormone).[10,11] Despite the reduction in mortality from ovarian cancer, several studies have reported that premenopausal bilateral oophorectomy is associated with several negative health outcomes, including increased risk of cardiovascular disease,[12–15] stroke,[16] cognitive impairment and dementia,[17,18] parkinsonism,[19,20] depression and anxiety,[21] and all-cause mortality, when compared with women in a reference group.[22]

Understanding time trends in the incidence of bilateral oophorectomy, by concurrent hysterectomy and by indication for oophorectomy (ovarian indication), will provide data for clinicians and patients to make informed treatment choices. Given the increasing literature regarding the long-term risks of premenopausal bilateral oophorectomy, ovarian conservation in the absence of cancer or high genetic risk for ovarian cancer has been recommended.[7,11,23] However, there are no clear clinical guidelines in the absence of malignancy, and it is not known whether the increased reporting of negative health effects has affected the incidence of bilateral oophorectomy. It is frequently stated that it takes an average of 17 years for research evidence to reach clinical practice.[24] Therefore, we examined the temporal trends of bilateral oophorectomy over a 69-year period, from January 1, 1950, through December 31, 2018, among women aged 18–49 years who were residents of Olmsted County, Minnesota. In addition, we examined temporal changes in premenopausal unilateral oophorectomy, which is also increasingly linked to long-term sequelae.[19,25] Incidence, by age and calendar year, was also stratified by women who underwent oophorectomy with or without concurrent hysterectomy, by ovarian indication for oophorectomy, and by ovarian pathology.

METHODS

This study was based on two previously described cohorts of women from MOA-1 and MOA-2 (Mayo Clinic Cohort Studies of Oophorectomy and Aging) who lived in Olmsted County, Minnesota. The first cohort included all women who underwent unilateral or bilateral oophorectomy from 1950 to 1987 (MOA-1),[13,26–28] and the second cohort included women who underwent unilateral or bilateral oophorectomy from 1988 to 2007 (MOA-2).[29,30] In addition, all women who were Olmsted County residents and underwent unilateral or bilateral oophorectomy from 2008 to 2018 (MOA-3; previously unpublished) were newly identified. Thus, in total, we studied the geographically defined population of Olmsted County, Minnesota, from January 1, 1950, through December 31, 2018 (69 years). Extensive details about the Olmsted County population have been reported elsewhere.[31–34] The study was approved by the Mayo Clinic and Olmsted Medical Center Institutional Review Boards.

Women who underwent unilateral or bilateral oophorectomy before spontaneous menopause and between the ages of 18 and 49 years were identified using resources of the Rochester Epidemiology Project, a unique, population-based medical records–linkage system. Residents of Olmsted County are served by a limited number of health care facilities, and all facilities participate in the medical records–linkage system. Thus, all medical visits and procedures are captured regardless of inpatient compared with outpatient status or insurance type. The nearest metropolitan area is 90 miles away (Minneapolis and Saint Paul), and the population is stable. Health care facilities include a tertiary care center; therefore, referrals for surgical treatment outside the county are limited.[31–34] However, a sizeable number of oophorectomies occur in a nontertiary care center within the county (specific percentage not disclosable). The methods used to identify women who underwent unilateral or bilateral oophorectomy have been described previously.[26,28,29] Briefly, the electronic indexes of the Rochester Epidemiology Project were searched for surgical procedure codes for unilateral or bilateral oophorectomy assigned from January 1, 1950, through December 31, 2018 (Appendix 1, available online at http://links.lww.com/AOG/C645). We included all women undergoing their first

unilateral oophorectomy (defined as complete removal of one ovary) or *bilateral oophorectomy* (defined as second unilateral oophorectomy or complete removal of both ovaries) during the study period.

Complete inpatient and outpatient medical records, including the surgeon's narrative report of the operation, were reviewed by several nurse abstractors in MOA-1, by a nurse abstractor and a physician (L.G.R.) in MOA-2, and by a graduate student (Z.E.) in MOA-3 to confirm the oophorectomy and to collect clinical information. Date of birth, race, date of surgical operation, type of oophorectomy, surgical indication, pathology results, and co-occurrence of hysterectomy at the time of oophorectomy were recorded. Indications included primary ovarian cancer, metastatic ovarian cancer (metastasis to the ovaries), risk reduction for women at high genetic risk of ovarian cancer (eg, strong family history or carriers of *BRCA* high-risk variants), suspicion of cancer or benign condition (eg, adnexal mass, endometriosis, cyst), torsion, and other condition (pelvic pain, abscess, oophoritis, ectopic pregnancy). A woman was considered to have no medical indication if the oophorectomy was performed during another surgical operation (eg, hysterectomy) and without any ovarian condition or was defined as elective by the surgeon. Each ovary could have more than one indication. A single indication was assigned to each unilateral or bilateral oophorectomy procedure using the most severe indication found, according to the order presented above.

The pathology report was based on an evaluation by a pathologist of frozen ovarian sections at the time of surgical operation and on the subsequent confirmation on permanent sections.[28–30] The medical records abstractor categorized pathology as primary ovarian cancer, metastatic cancer, benign ovarian tumor (eg, cystadenoma, dermoid cyst, fibroma, teratoma), endometriosis, oophoritis, cyst, other inflammatory process (eg, abscess, adhesions), atrophy, or other ovarian lesions (eg, torsion, fibrosis, thecosis, endosalpingiosis, hemorrhage). Ovaries that had no pathologic diagnoses were labeled as "apparently normal." Each ovary could have more than one pathologic finding. A single pathology category was assigned to each unilateral or bilateral oophorectomy using the most severe pathology result found, according to the order presented above.[30]

Incidence rates were calculated by dividing the number of women who underwent a first unilateral oophorectomy or bilateral oophorectomy by the person-years at-risk in the Olmsted County population and multiplying by 100,000. Population denominators were derived from the U.S. Decennial Censuses for the years 1950–2010, and intercensal year population denominators were linearly interpolated. For 2011–2018, the annual population denominators were obtained from the U.S. Census Bureau Population Estimates Program (Vintage 2019, accessed 09/1/2020, available at https://www.census.gov/data/tables/time-series/demo/popest/2010s-counties-total.html). Where appropriate, overall incidence rates were age-adjusted to the total U.S. female population from the 2010 Census. Race was considered as a possible confounder.

Incidence rates were calculated by age group at oophorectomy (5-year increments, with 7 years in the first age group of 18–24) over the entire 69-year period, by calendar year of oophorectomy (5-year increments, with 4 years in the final calendar group of 2015–2018), and by age group within each calendar year group. Separate incidence rates were also calculated by 5-year calendar group within broader age groups based on conventional definitions of premature menopause (younger than 40 years), early menopause (40–45 years), and normal menopause (46–49 years).[7] These separate rates were further stratified by women who underwent oophorectomy with or without concurrent hysterectomy, by ovarian indication for oophorectomy, and by ovarian pathology results.

Distributions of the demographic and surgical characteristics of the unilateral or bilateral oophorectomy procedures were compared using χ^2 tests. All analyses were conducted using SAS 9.4, and tests of significance were undertaken at the two-tailed α level of 0.05.

RESULTS

Between January 1, 1950, and December 31, 2018 (69 years), 5,044 women between the ages of 18 and 49 years who were residents of Olmsted County, Minnesota, underwent unilateral or bilateral oophorectomy before spontaneous menopause (n=5,154 procedures, Fig. 1). A total of 2,092 (40.6%) women underwent a first unilateral oophorectomy. Among the 3,062 (59.4%) women who underwent bilateral oophorectomy, 257 (8.4%) underwent subsequent unilateral oophorectomy to remove the remaining ovary and 2,805 (91.6%) had both ovaries removed concurrently. Table 1 presents the demographic and surgical characteristics for unilateral and bilateral oophorectomy separately. The most common indication for unilateral oophorectomy was suspicion of cancer or benign disease (72.6%); the most common indication for bilateral oophorectomy was "elective" (49.1%). The most frequent pathology for unilateral oophorectomy was a cyst (30.0%), and the most frequent pathology for bilateral oophorectomy was normal pathology (42.1%). Primary or metastatic ovarian cancer was found at

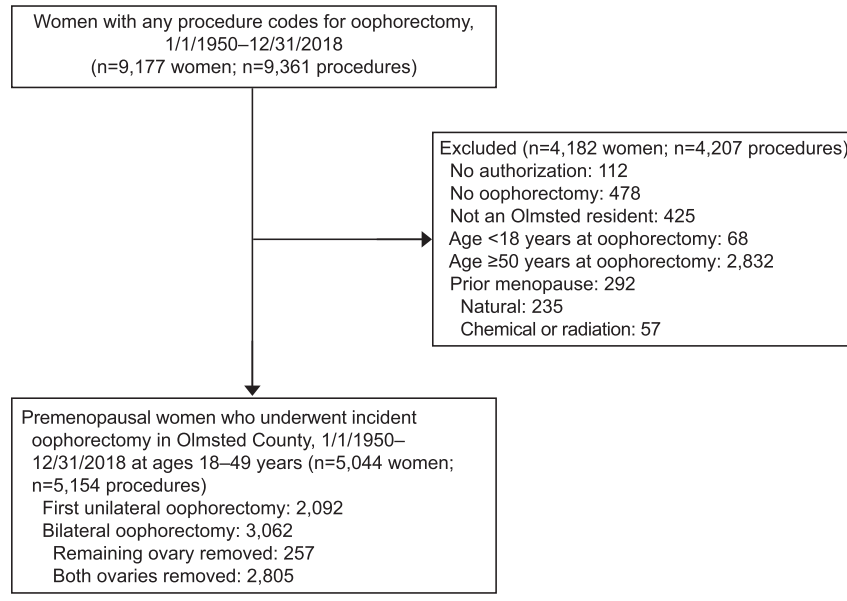

Fig. 1. Flowchart of the study cohort. We included all women undergoing their first unilateral oophorectomy (defined as complete removal of one ovary) or bilateral oophorectomy (defined as second unilateral oophorectomy or complete removal of both ovaries) during the study period. Therefore, some women had more than one procedure during the study period and were counted twice. By contrast, the procedures were counted separately in the flowchart.

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pathology in only 1.3% of unilateral oophorectomies and 4.0% of bilateral oophorectomies.

Table 2 shows the incidence of unilateral and bilateral oophorectomy overall and by 5-year calendar group and 5-year age group per 100,000 person-years. The incidence of unilateral oophorectomy was higher than bilateral oophorectomy for women between the ages of 18 and 39 years, whereas the incidence of bilateral oophorectomy was higher than unilateral oophorectomy for women aged 40–49 years (Fig. 2A). The incidence of bilateral oophorectomy reached a peak of 626 per 100,000 person-years for women aged 45–49 years; unilateral oophorectomy peaked for women aged 40–44 years at 215 per 100,000 person-years. Figure 2B displays the incidence per 100,000 person-years of unilateral and bilateral oophorectomy by calendar year (5-year groups). More than half (n=1,750, 57.2%) of the bilateral oophorectomies performed in Olmsted County, Minnesota, during the entire 69-year period occurred in the 20 years between 1990 and 2009. Unilateral oophorectomy was more common than bilateral oophorectomy between 1950 and 1969 and was approximately equally common in 1970–1984. From 1980–1984 until 2000–2004, the incidence of bilateral oophorectomy more than doubled and the incidence of unilateral oophorectomy declined. However, after 2005, both procedures declined, and the incidence of unilateral and bilateral oophorectomy was similar in 2015–2018. Appendix 2, available online at http://links.lww.com/AOG/C645, shows the detailed incidence rates by 5-year age groups within each 5-year calendar group.

We replicated the above analyses for unilateral and bilateral oophorectomy stratified by concurrent hysterectomy status. Of the women who underwent unilateral oophorectomy, 1,108 (53.0%) had concurrent hysterectomy, compared with 2,690 (87.9%) women who underwent bilateral oophorectomy (Table 1). Figure 3 shows the comparison of trends in the incidence of unilateral and bilateral oophorectomy with and without concurrent hysterectomy by broad age group (younger than 40 years, premature menopause; 40–45 years, early menopause; 46–49 years, normal menopause) and by 5-year calendar group. Starting in 1985, among women aged 40–45 and 46–49 years with concurrent hysterectomy, the incidence of bilateral oophorectomy ranged from 2.1 to 29.2 times higher than unilateral oophorectomy. Among women aged younger than 40 years with concurrent hysterectomy, the incidence of unilateral oophorectomy was the same as or higher than bilateral oophorectomy between 1950 and 1984 but lower between 1985 and 2018. For all age groups, the incidence of bilateral oophorectomy with concurrent hysterectomy declined after 2000. Among women aged younger than 40 years without concurrent hysterectomy, the incidence of unilateral oophorectomy was higher than bilateral oophorectomy. By contrast, the incidence of unilateral and bilateral oophorectomy was similar for women aged 40–45 and 46–49 years without concurrent hysterectomy, and the overall incidence was low across the entire study period.

Figure 4 shows the incidence of unilateral and bilateral oophorectomy after stratification by ovarian

Table 1. Demographic and Surgical Characteristics For All Incident Oophorectomies Performed From 1950 to 2018

Characteristic	Type of Oophorectomy		P[‡]
	Unilateral (n=2,092)*	Bilateral (n=3,062)[†]	
Ovary removed			<.001
Left	1,150 (55.0)	120 (3.9)[†]	
Right	942 (45.0)	137 (4.5)[†]	
Both	NA	2,805 (91.6)	
Age at oophorectomy (y)			<.001
18–24	170 (8.1)	23 (0.8)	
25–29	247 (11.8)	65 (2.1)	
30–34	375 (17.9)	219 (7.2)	
35–39	473 (22.6)	429 (14.0)	
40–44	501 (24.0)	932 (30.4)	
45–49	326 (15.6)	1,394 (45.5)	
Study years			<.001
1950–1954	95 (4.5)	74 (2.4)	
1955–1959	99 (4.7)	54 (1.8)	
1960–1964	148 (7.1)	57 (1.9)	
1965–1969	160 (7.6)	99 (3.2)	
1970–1974	216 (10.3)	201 (6.6)	
1975–1979	225 (10.8)	143 (4.7)	
1980–1984	170 (8.1)	148 (4.8)	
1985–1989	188 (9.0)	271 (8.9)	
1990–1994	99 (4.7)	365 (11.9)	
1995–1999	134 (6.4)	503 (16.4)	
2000–2004	146 (7.0)	554 (18.1)	
2005–2009	173 (8.3)	328 (10.7)	
2010–2014	146 (7.0)	187 (6.1)	
2015–2018	93 (4.4)	78 (2.5)	
Race[§]			<.001
American Indian or Native Alaskan	2 (0.1)	5 (0.2)	
Asian	34 (1.6)	33 (1.1)	
Black	40 (1.9)	37 (1.2)	
White	1,950 (93.2)	2,961 (96.7)	
None of the above	45 (2.2)	18 (0.6)	
Unknown	21 (1.0)	8 (0.3)	
Hispanic ethnicity[§]	39 (1.9)	45 (1.5)	<.001
Indication[‖]			<.001
Primary cancer	5 (0.2)	50 (1.6)	
Metastatic cancer	6 (0.3)	58 (1.9)	
Risk reduction	1 (0.0)	131 (4.3)	
Suspicion of cancer or benign conditions	1,519 (72.6)	1,286 (42.0)	
Torsion	61 (2.9)	8 (0.3)	
Other ovarian indication	54 (2.6)	26 (0.8)	
Elective	446 (21.3)	1,503 (49.1)	
Pathology[¶]			<.001
Primary cancer	24 (1.1)	90 (2.9)	
Metastatic cancer	4 (0.2)	33 (1.1)	
Benign tumor	430 (20.6)	293 (9.6)	
Endometriosis	329 (15.7)	544 (17.8)	
Oophoritis	86 (4.1)	71 (2.3)	
Cyst	628 (30.0)	644 (21.0)	
Inflammatory process	81 (3.9)	48 (1.6)	
Atrophy	7 (0.3)	7 (0.2)	
Other ovarian pathology	66 (3.2)	35 (1.1)	

(*continued*)

Table 1. Demographic and Surgical Characteristics For All Incident Oophorectomies Performed From 1950 to 2018 (*continued*)

Characteristic	Type of Oophorectomy		$P^{\ddagger}$
	Unilateral (n=2,092)*	Bilateral (n=3,062)†	
Normal	421 (20.1)	1,288 (42.1)	
Unknown	16 (0.8)	9 (0.3)	
Hysterectomy status			<.001
None	872 (41.7)	125 (4.1)	
Before oophorectomy	112 (5.4)	247 (8.1)	
Concurrent with oophorectomy	1,108 (53.0)	2,690 (87.9)	

NA, not applicable.
Data are n (%) unless otherwise specified.
* First unilateral oophorectomy.
† Bilateral oophorectomy (both ovaries removed during the same procedure) or second unilateral oophorectomy (remaining ovary removed).
‡ *P* values were calculated using χ^2 tests.
§ Race was collected using information documented in the medical record and considered as a possible confounder. The category "None of the above" included women with more than one race.
‖ The indication was listed by the gynecologist in the medical record at the time of oophorectomy. Benign conditions included benign tumors, cysts, and endometriosis. For women with more than one indication present, we reported the most severe indication (in the order shown).
¶ The pathology results were determined by a pathologist after the oophorectomy. Benign tumors included cystadenomas, dermoid cysts, fibromas, and teratomas. For women with more than one result, we reported the most severe pathology (in the order shown).

indication (cancer, benign, or without any), by broad age group (younger than 40, 40–45, 46–49 years), and by 5-year calendar group. Over the 69-year study period, the incidence of unilateral and bilateral oophorectomy for cancer indication remained stable, whereas unilateral oophorectomy with benign ovarian indication had a gradual downward trend for all ages. For women younger than age 40 years with benign ovarian indication, unilateral oophorectomy was consistently more common than bilateral oophorectomy across the 69-year observation period. Among women aged 40–45 and 46–49 years without an ovarian indication, the incidence of bilateral oophorectomy more than doubled between 1960–1964 and 1980–1984 and doubled again between 1980–1984 and 1995–1999, after which the incidence declined to levels more similar to unilateral oophorectomy. The time trends in incidence stratified by ovarian pathology (cancer, benign, or normal) were similar to the trends in incidence by ovarian indication (Appendix 3, available online at http://links.lww.com/AOG/C645).

DISCUSSION

In this population-based study of female residents of Olmsted County, Minnesota, we observed temporal trends in the incidence of premenopausal unilateral and bilateral oophorectomy over a 69-year period that differed by age, calendar year, concurrent hysterectomy, and ovarian indications. Although there were increases

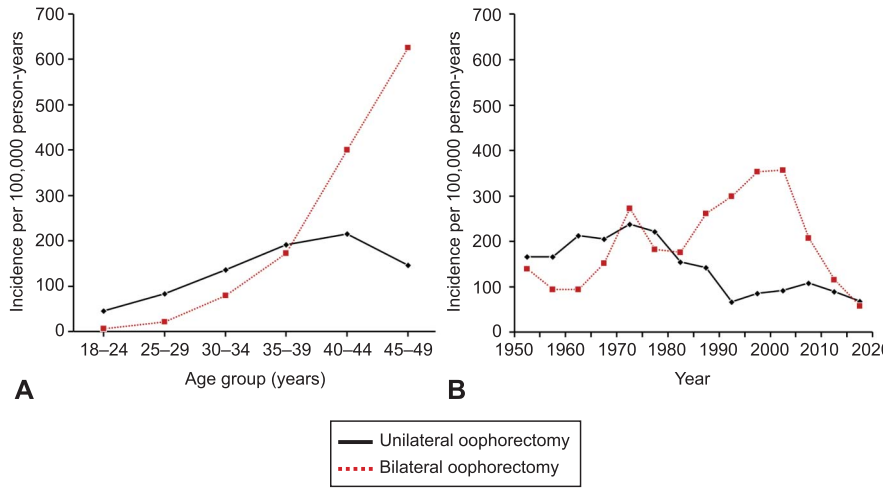

Fig. 2. Incidence per 100,000 person-years of premenopausal unilateral and bilateral oophorectomy in Olmsted County, Minnesota, shown by 5-year age groups from age 18 to 49 years (**A**) and by 5-year calendar groups from 1950 to 2018 (**B**). The incidence rates in **B** were age-adjusted to the total U.S. female population from the 2010 Census.

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Table 2. Incidence of Oophorectomy in Olmsted County, Minnesota, 1950–2018, Performed at Age 18–49 Years, Overall and By Age at Oophorectomy and By Calendar Year (Per 100,000 Person-Years)

		Unilateral Oophorectomy		Bilateral Oophorectomy	
Group	Person-Years	n	Incidence (95% CI)* (Per 100,000 Person-Years)	n	Incidence (95% CI)* (Per 100,000 Person-Years)
Overall†	1,656,703	2,092	130 (124–135)	3,062	211 (204–219)
Age group (y)					
18–24	379,878	170	45 (38–52)	23	6 (4–9)
25–29	298,419	247	83 (73–94)	65	22 (17–28)
30–34	275,373	375	136 (123–151)	219	80 (69–91)
35–39	247,503	473	191 (174–209)	429	173 (157–191)
40–44	232,868	501	215 (197–235)	932	400 (375–427)
45–49	222,663	326	146 (131–163)	1,394	626 (594–660)
Calendar year†					
1950–1954	62,777	95	166 (132–199)	74	140 (108–172)
1955–1959	68,558	99	166 (133–199)	54	94 (68–119)
1960–1964	76,989	148	213 (178–248)	57	95 (70–120)
1965–1969	89,407	160	205 (172–238)	99	152 (122–182)
1970–1974	101,522	216	238 (205–270)	201	273 (234–312)
1975–1979	113,207	225	222 (192–252)	143	182 (151–212)
1980–1984	123,648	170	155 (131–179)	148	176 (147–205)
1985–1989	132,269	188	143 (122–165)	271	262 (230–293)
1990–1994	139,863	99	67 (54–81)	365	299 (267–330)
1995–1999	145,954	134	86 (71–101)	503	354 (323–385)
2000–2004	151,296	146	92 (77–107)	554	357 (327–386)
2005–2009	155,537	173	109 (92–125)	328	208 (186–231)
2010–2014	161,005	146	90 (75–104)	187	116 (99–133)
2015–2018	134,671	93	68 (54–82)	78	58 (45–71)

* Incidence rates were calculated by dividing the number of women who underwent a first unilateral oophorectomy or bilateral oophorectomy by the person-years at-risk in the Olmsted County, Minnesota, population and multiplying by 100,000.

† The overall and calendar year–specific incidence rates were age-adjusted to the total U.S. female population from the 2010 Census. Therefore, although the age group–specific incidence rates can be obtained by dividing the number of women by the corresponding person-years within each age group, the overall and the calendar year–specific incidence rates cannot be directly obtained by similar arithmetic.

in the incidence of premenopausal bilateral oophorectomy up to about 2000–2004, there have been notable decreases in its incidence over the past 14 years (2005–2018). This decrease was primarily among women with concurrent hysterectomy or without an ovarian indication. The incidence of premenopausal unilateral oophorectomy also decreased, albeit less dramatically than bilateral oophorectomy. These results suggest a recent change in the clinical practice of oophorectomy among premenopausal women in Olmsted County, Minnesota, especially among women undergoing hysterectomy and those without an ovarian indication.

Historically, gynecologists were taught to remove the ovaries prophylactically in most women undergoing hysterectomy as a way of preventing ovarian cancer.[9,35] From 1965 to 1999, the percentage of hysterectomies for benign indications performed with concurrent oophorectomy increased from 25% to 55% in New York.[36] Similarly, using the Nationwide Inpatient Sample of the Healthcare Cost and Utilization Project, the rate of bilateral oophorectomy with concurrent hysterectomy increased from 7.8 per 10,000 person-years in 1998 to 9.0 per 10,000 person-years in 2001.[5] Our findings in Olmsted County, Minnesota, demonstrate a similar upward trend in the incidence of bilateral oophorectomy with concurrent hysterectomy at age 40–45 years during a similar timeframe.

Because ovarian cancer often is not detected until advanced stages, the cost–benefit ratio for prophylactic oophorectomy, even among women at average risk for ovarian cancer, was historically considered to be high. However, with increasing awareness of the longer-term negative outcomes of premenopausal oophorectomy, the cost–benefit ratio began to change starting in 2005–2006.[8,27,35] Indeed, a younger age at premenopausal bilateral oophorectomy has been associated with increased overall mortality, cardiovascular disease, and cognitive impairment or dementia, among other negative outcomes.[7,12–19,21]

In 2008, the American College of Obstetricians and Gynecologists changed its recommendations regarding oophorectomy and encouraged retention

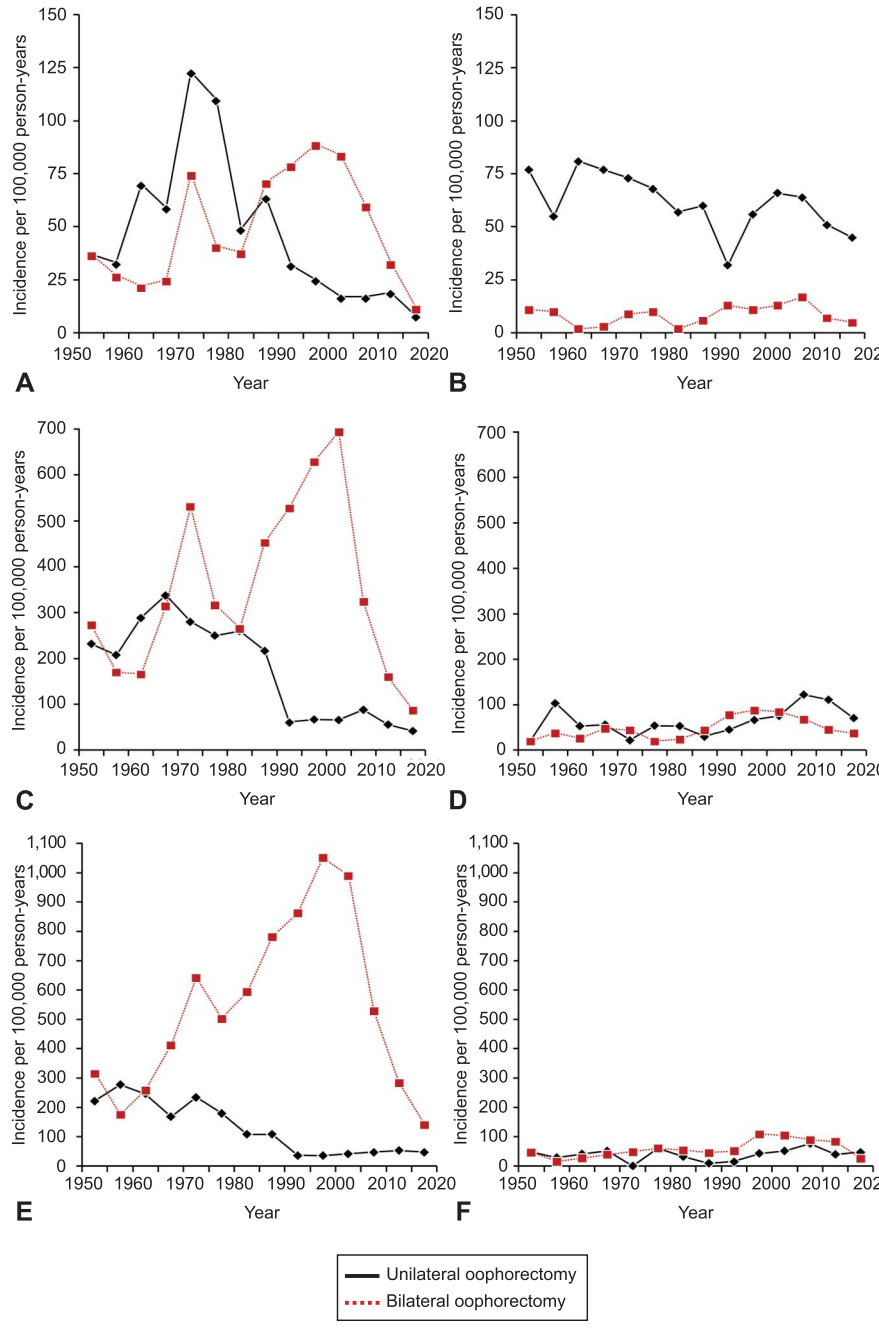

Fig. 3. Incidence per 100,000 person-years of premenopausal unilateral or bilateral oophorectomy with (**A**, **C**, **E**) and without (**B**, **D**, **F**) concurrent hysterectomy across three age groups (younger than 40 [**A**, **B**], 40–45 [**C**, **D**], and 46–49 [**E**, **F**] years) and by 5-year calendar groups from 1950 to 2018. Note that the y-axis scale differs for each age group.

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of both ovaries in premenopausal women who did not have an increased genetic risk (ie, carriers of *BRCA* high-risk variants) or an indication for ovarian removal,[37] reflecting a change in attitude toward the practice. The present results in Olmsted County, Minnesota, suggest that this recommendation, even if not a clinical guideline, and the growing body of literature confirming the long-term negative outcomes have contributed to decreases in the incidence of premenopausal oophorectomy, especially among premenopausal women undergoing hysterectomy and women without an ovarian indication. Two previous studies report decreases in the rate of overall oophorectomy across multiple states up to 2011[38,39]; however, our results suggest that a further rapid decrease may have occurred over the past 7 years.

A strength of the current study is the population-based design capturing all female residents of Olmsted County, Minnesota, from 1950 to 2018 regardless of

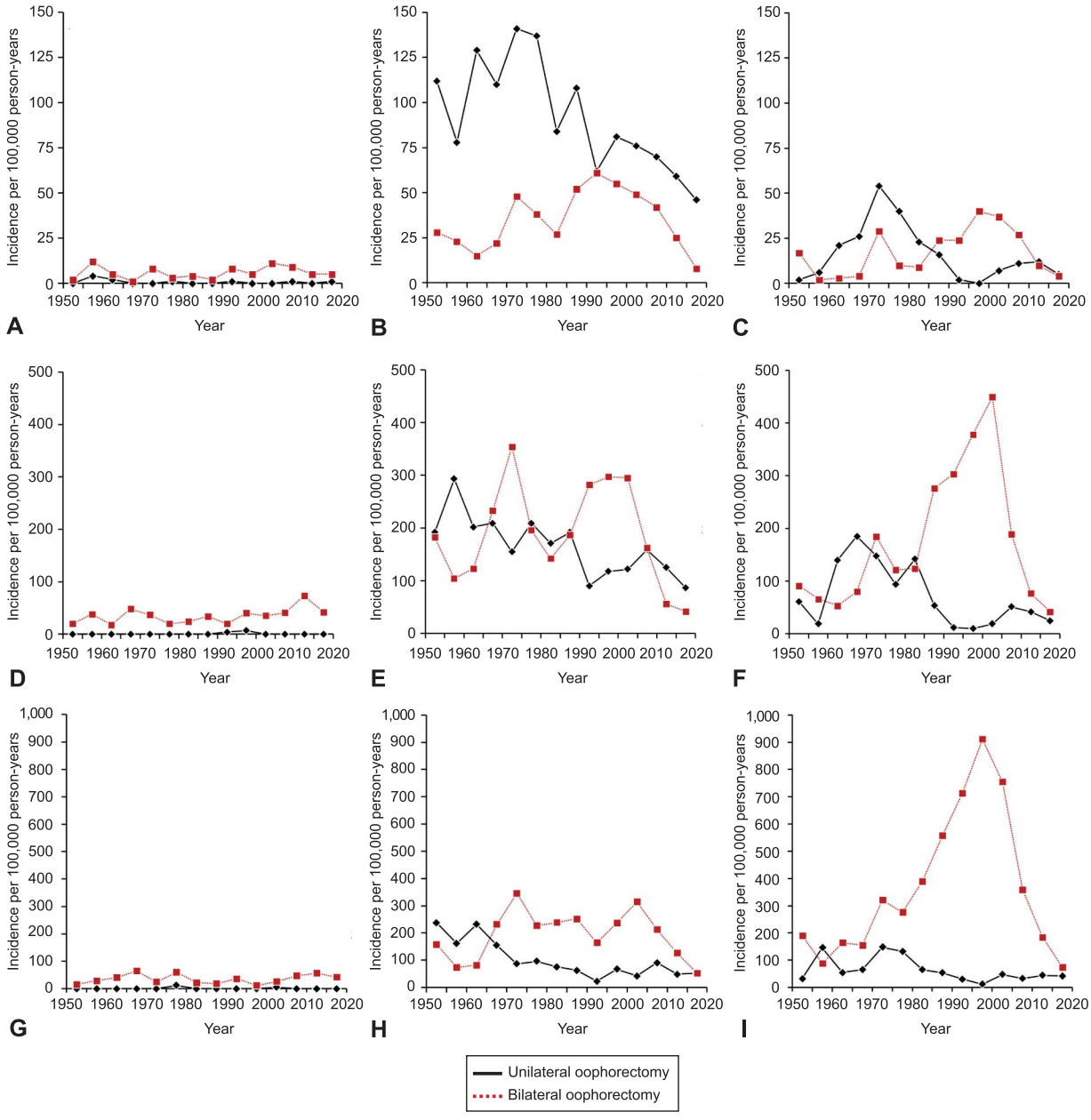

Fig. 4. Incidence per 100,000 person-years by ovarian indication for premenopausal unilateral or bilateral oophorectomy across three age groups (younger than 40 [**A–C**], 40–45 [**D–F**], and 46–49 [**G–I**] years) and by 5-year calendar groups from 1950 to 2018. Note that the y-axis scale differs for each age group. The indication was listed by the gynecologist at the time of the oophorectomy. For women with more than one result, we reported the most severe indication. Cancer indication (**A**, **D**, **G**) includes primary and metastatic ovarian malignancy and risk-reduction surgery for women at high genetic risk of ovarian cancer. Benign ovarian indication (**B**, **E**, **H**) includes suspicion of cancer or benign condition (eg, adnexal mass, endometriosis, cyst), torsion, or other condition (pelvic pain, abscess, oophoritis, ectopic pregnancy). The third group of women did not have any ovarian indication (**C**, **F**, **I**).

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insurance type, surgery type, or inpatient compared with outpatient procedure. This is advantageous over other studies that had access only to inpatient data, especially because hysterectomies and oophorectomies are increasingly being performed in outpatient settings.[40] In addition, all procedures were confirmed by review of the medical records by trained abstractors.

However, limitations also warrant consideration. Results from Olmsted County, Minnesota, may not be generalizable to other populations or regions of the country, because women in this county are primarily of European descent. Although similar trends have been reported for some states,[36,39] the incidence of hysterectomy, including hysterectomy with concurrent bilateral oophorectomy, has been shown to vary by geographic region as well as by economic and sociologic indicators.[9,41] For example, a recent study reports that the rates of bilateral oophorectomy in North Carolina increased between 2011 and 2014, especially among non-Hispanic Black women.[40] In addition, we did not consider changes in surgical procedures that could affect the incidence of premenopausal oophorectomy (ie, abdominal or vaginal vs laparoscopic or robotic).[42,43] It is possible that the increasing use of laparoscopic surgery could lead to increasing rates of bilateral oophorectomy.[40] However, despite these changes in technology, we still observed a decrease in oophorectomy incidence. Last, we did not abstract information on other surgeries on the adnexa that could decrease ovarian or pelvic cancer risk, such as partial or total salpingectomy. Future studies will need to assess trends in these surgeries in comparison with oophorectomy.

Women who are at high genetic risk for ovarian cancer (ie, carriers of *BRCA* high-risk variants) are recommended to undergo premenopausal bilateral oophorectomy.[44] However, given the increasing literature suggesting long-term negative effects of premenopausal bilateral oophorectomy, the risk–benefit ratio of the procedure is changing for women at average genetic risk. The current study suggests that trends in premenopausal bilateral oophorectomy, especially with concurrent hysterectomy or without an ovarian indication, are decreasing in Olmsted County, Minnesota. Therefore, the recommendations from the American College of Obstetricians and Gynecologists and the growing body of research evidence are having the appropriate effect on gynecologic practice. If we accept 2005–2006 as the turning point in the research evidence against widespread use of bilateral oophorectomy in premenopausal women as a preventive measure,[8,27,35] the translation of research evidence into practice may have been more rapid than the predicted 17-year gap.[24] We have reasons for cautious optimism, at least in populations with access to quality care. However, disparities in care by race and ethnicity are partly responsible for the persisting geographic variations in care within the United States. Additional understanding of the cause of these disparities, and outreach and education, are needed so that all women receive the most appropriate care.

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