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WHEN DOES FERTILITY END? THE TIMING OF TUBAL LIGATIONS AND HYSTERECTOMIES, AND THE MEANING OF MENOPAUSE

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Abstract

We applied a biocultural lens to examine the temporal order of biological, behavioral, and medical events related to fertility across the female reproductive lifespan in three sites, two in Mexico and one in the United States. Using a mixed-method design, we expanded our thinking about the end of fertility in order to examine the timing of hysterectomies and tubal ligations. We discovered that menopause is not the end of fertility for a surprisingly high number of women. Across the three sites, between 43% and 50% of women underwent tubal ligations at mean ages of 32 years (in Campeche, Mexico) and 33 years (Puebla, Mexico). In Puebla, 23% had a history of hysterectomy at a mean age of 42 years, similar to Hilo, Hawaii, where 20% had undergone a hysterectomy at a mean age of 40 years. We hypothesized that women who underwent tubal ligations would less frequently describe menopause as the end of fertility. This was true in Hilo, Hawaii, where women with a history of tubal ligation were almost half as likely to choose “loss of fertility” to describe menopause. However, in urban and rural Campeche, Mexico, there was no indication – from either quantitative or qualitative responses – that individuals with a history of tubal ligation or hysterectomy were less likely to describe menopause as the end of fertility.

Keywords: menopause; hysterectomy; tubal ligation; sterilization; fertility

Anthropology & Aging, Vol 42, No 1 (2021), pp. 10-29

ISSN 2374-2267 (online) DOI 10.5195/aa.2021.254



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WHEN DOES FERTILITY END? THE TIMING OF TUBAL LIGATIONS AND HYSTERECTOMIES, AND THE MEANING OF MENOPAUSE

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Introduction

Across the female lifespan, fertility¹ is an imagined potential that starts and stops with the onset and cessation of menstruation. Fertility is invisible to the eye (Inhorn 2015) but assumed (without evidence to the contrary) and managed through the use of contraceptives as part of a lifelong interplay between reproduction and technology (Franklin 1997). Our focus on fertility introduces the biology of menarche and menopause into the chronologized life course (Kohli and Meyer 1986), along with the conventional understanding that fertility declines with advancing age. Based on work in rural Gambia, Caroline Bledsoe (2002) outlined two ways of perceiving the decline in female reproductive capacity with age and how those perceptions relate to the use of birth control. The “linear” perception understands an abstract, universal, and naturalized loss of fertility, ending with menopause. The “contingent” viewpoint situates the decline of reproductive capacity within the context of women’s health, social circumstances, and personal actions, including the use of contraception. In the study presented here, we examine fertility from the latter point of view – as conditional and dependent on a woman’s history of hysterectomy and/or tubal ligation. Reproductive capacity from menarche to menopause does not always follow a linear path from a peak through a gradual decline. Sometimes reproductive capacity is sharply truncated by sterilization. Here we apply a biocultural perspective to examine the chronology of biological, behavioral, and medical events potentially associated with the “biological clock” of reproductive aging, as well as variation in the experience and perception of reproductive capacity and menopause.

Menarche, the first menstruation, occurs just after the peak of the adolescent growth spurt and indicates the beginning of hypothalamic-pituitary-ovarian cyclicality, although not necessarily the start of fertility. Even if menarche coincides with sexual activity, there is generally a period of adolescent sterility (or subfecundity) that reduces the chance of pregnancy (Wood 1994).

Menopause, the last menstrual period, is identified in retrospect after twelve months without menstruation. Clinically, menopause marks the end of the peri-menopause and the beginning of the early post-menopausal stage (Harlow *et al.* 2012). For women, the last menstrual period can mean many things, including the end of fertility, no need for contraception, and no more fear of pregnancy (Dillaway 2005; Hvas 2006; Lindh-Astrand *et al.* 2007; Morrison *et al.* 2014; Utz 2011).

Although women may think of menopause as the end of fertility, menopause is not synchronous with the end of fertility, just as menarche is not synchronous with the start of fertility. Fertility ends before the last menstrual period, as documented by studies of anti-Müllerian hormone (AMH) which is

produced by ovarian follicles. Years before the last menstrual period, AMH levels fall so low as to be undetectable (Depmann 2016; Kelsey *et al.* 2011; Kim *et al.* 2017). Low levels of AMH indicate that ovarian follicles are not developing, there will be no egg produced by the ovaries, and the woman cannot conceive a child, even though she may still have menstrual cycles. Thus, there is a period of subfecundity prior to the last menstrual period (Wood 1994).

In the absence of laboratory tests for ovarian function (e.g., falling levels of AMH or rising levels of follicle stimulating hormone; Kim *et al.* 2017) menopause and the end of fertility become conflated. For example, one researcher matter-of-factly described the end of menstruation as the “undeniable end of a woman’s ability to procreate” (Utz 2011,144). In Denmark, Hvas (2006) found that menopause was perceived to be “a milestone marking the end of the child-bearing years” (247). For many women, menopause silences the ticking of the biological clock. As a result, menopause may be associated with grief or relief (de Salis *et al.* 2017; Dillaway 2005; Khademi and Cooke 2003; Martin 1993). In a qualitative study (Morrison *et al.* 2014) of attitudes toward menopause in Hilo, Hawaii, some women described themselves as “infertile” and expressed sadness or ambivalence. For example, “I have mixed feelings, I’m looking forward to [menopause] and mmm, I feel kind of sad about not being fertile anymore, but I think I’m going through acceptance” (8). Menopause is a “time when you aren’t able to reproduce anymore, a time when maybe it’s the autumn season, or winter season” (Morrison *et al.* 2014, 538-539). In a qualitative study by de Salis *et al.* (2017) a nurse in the U.K. explained:

I did, actually, mourn the passing of a phase of my life because I thought, this is a phase where you’re, kind of, fertile, and, you know, you’ve been doing this since you were 12, or whatever. You have your little cycle and then suddenly it’s not going to be happening. And it’s like, you know, it’s a bit of a realization that you are mortal, and things pack up, and you’ve reached this, sort of, your biological usefulness is over. You know what I mean? As a species, you can go now, you’ve done what you need to do, you’ve reproduced. . . . Like the old, sort of, withered apple on the tree, you know, there’s no seeds in it! (de Salis *et al.* 2017, 9).

In the study presented here, we question the interpretation of menopause as the end of fertility by looking beyond the loss of ovarian follicles. The end of childbearing can be brought about in various ways. For example, in some societies women have been expected to practice terminal abstinence. In this case, sexual activity is avoided by women after their own daughters start to have children, perhaps to avoid competition for resources between children and grandchildren (Caldwell and Caldwell 1977; Leidy 1993). The upper parameter of the reproductive period can also be permanently altered through biomedical interventions, such as hysterectomy (removal of the uterus), oophorectomy (removal of the ovaries), or sterilization by tubal ligation (cutting or blocking the fallopian tubes). Additionally, the reproductive span can be lengthened through assisted fertility practices that make it possible for women of 66, 67, and even 70 years of age to carry a pregnancy to term with a donated egg (Banh 2010; Cutas and Smajdor 2015; Majumdar, this issue). Figure 1 illustrates the potential temporal order of these biological, behavioral, and medical events during the reproductive period.

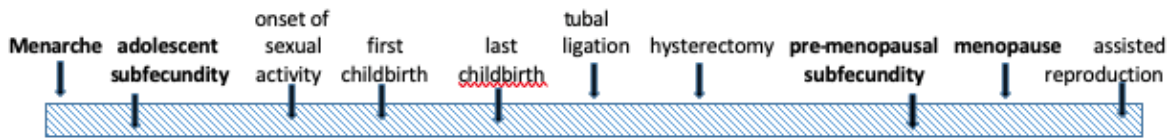


Figure 1: The temporal order of biological, behavioral, and medical events that may occur during the reproductive period and are potentially associated with the “biological clock.”

The purpose of this study was to use existing data to examine the frequency and timing of tubal ligations and hysterectomies in three sites, two in Mexico and one in the United States. These populations were chosen because of the relatively high frequency of hysterectomies in Hilo, Hawaii (Sievert *et al.* 2013) and Puebla, Mexico (Sievert and Hautaniemi 2003), and because of the relatively high frequency of tubal ligations in Hilo, Puebla (Rudzik *et al.* 2011), and Campeche, Mexico. Our intent was to illustrate how menopause is the “end of fertility” for a surprisingly high number of women who experienced tubal ligations, hysterectomies, or both. In addition, we hypothesized that women who underwent tubal ligations would less frequently describe menopause as a freedom from pregnancy or as the end of fertility.

Samples and methods

Campeche, Mexico

We first carried out a qualitative pilot study in 2012 (Huicochea *et al.* 2017), followed by a mixed-methods investigation of symptom experience at midlife in the state of Campeche from 2013 to 2015. Our primary focus was to compare the experience of hot flashes between Maya and non-Maya women living in 12 sites across three municipalities (Campeche, Hopelchén, and Calakmul). We compared: i) the capital city of Campeche, ii) two rural Maya communities within 40 km of the capital (Hopelchén Norte), iii) four rural, isolated non-Maya communities in Calakmul, and iv) five rural, isolated Maya communities (Hopelchén Sur). In the city, women were drawn from offices, businesses, schools, the city market, and by giving presentations to groups of women in private homes in eight neighborhoods. In the rural communities, women were invited to participate through the support of local medical providers, following presentations to community leaders and the public (Sievert *et al.* 2019). In total, an opportunity sample of 543 women aged 40-60 years participated in face-to-face interviews and anthropometric measures. Ethical approval for this study in Campeche was obtained from the Institutional Review Boards of UMass Amherst, the University of Hawaii at Hilo, and the Comité de Ética de la Secretaría de Salud del Estado de Campeche.

Semi-structured interviews were carried out in Spanish to collect demographic, biobehavioral, and reproductive information, including age at first menstruation, number of children, dates of births of first and last child, date of last menstruation, history of birth control (including age at tubal ligation), and history of hysterectomy or oophorectomy, at what age, and why. Menstruation was carefully queried in order to classify women as i) regular, ii) having changes in quantity or frequency of menstruation, iii) experiencing more than six days of difference in cycles, iv) experiencing two or more months without menses, or v) experiencing more than twelve months without menses. Additionally, an index of socioeconomic status was constructed (Sievert *et al.* 2019).

Women were also asked 21 structured questions about their perceptions related to menopause. For the analyses presented here, we focused on three questions: “Do you feel that it is a freedom, to know that there is no risk of pregnancy?” (*¿Siente que es una liberación saber que no hay riesgo de embarazo?*); “Can

you better enjoy sexual relations with your partner?" (*¿Puede disfrutar más las relaciones sexuales con su pareja?*); and "Do you see this as an easier and more tranquil stage of life?" (*¿En esta etapa ve la vida más fácil y tranquila?*). In addition, women were asked the open-ended question, "What is menopause?" (*¿Qué es la menopausia?*).

Puebla, Mexico

A study of age at menopause and symptom experience at midlife was carried out in Puebla, Mexico from 1999 to 2000. Puebla is the capital of the state of Puebla, 130 km from Mexico City, with about 1.5 million residents at the time of study. An opportunistic sample of 755 women, aged 40 to 60 years, was drawn from across socioeconomic strata of the city through invitations extended to women in parks, at bus stops, in open-air markets, in front of a hospital, and at other public sites (for sampling details and a map, see Sievert and Hautaniemi 2003). In face-to-face interviews, women were asked the date of their last menstrual period, whether they had undergone a tubal ligation (yes/no) and age at tubal ligation, whether they had undergone a hysterectomy (yes/no), when, and why, along with many other demographic, reproductive, lifestyle, and health-related questions (Rudzik *et al.* 2011; Sievert 2006; Sievert and Espinosa-Hernandez 2003). Ethical approval for this study in Puebla was obtained from the Institutional Review Board of UMass Amherst. All interviews were carried out in Spanish.

Hilo, Hawai'i

A study of age at menopause, symptoms at midlife, and blood pressure was carried out in the multi-ethnic city of Hilo, Hawai'i from 2004 to 2005 (Brown *et al.* 2011). Hilo is the county seat of the Big Island, with a census of about 46,000 residents. A postal survey was mailed to a randomly generated sample of women within the city and was returned by 1824 women (Sievert *et al.* 2007). Participants aged 40-60 years who identified themselves as European-American, Japanese-American, or of Mixed ancestry (including those of Hawaiian descent) are included in the analyses presented here (n=793). The postal survey queried marital status, economic comfort (struggling, OK, comfortable, well-off), age at first menstruation, age at last menstruation, menstrual cycle characteristics, ages at birth of first and last child, use of birth control, history of tubal ligation (yes/no), and history of hysterectomy (yes/no), when, and whether women were still menstruating just before they underwent the hysterectomy. Women were also asked, "How would you describe menopause?" and asked to check any of eight possible characteristics: freedom, natural, loss of fertility, eagerly awaited, onset of old age, loss of femininity, a nuisance, and/or no problem (Morrison *et al.* 2010). In a study that included all participants aged 16-100 years, 26% of pre-menopausal, 29% of peri-menopausal, and 21% of post-menopausal women described menopause as a loss of fertility (Morrison *et al.* 2010). Ethical approval for this study in Hawai'i was obtained from the Institutional Review Boards of UMass Amherst and the University of Hawaii at Hilo.

Analyses

Descriptive statistics were carried out, and frequency of menopause, hysterectomy, and tubal ligations were compared across four subsamples in Campeche and three subsamples in Hilo, Hawaii, by chi-square and ANOVA as appropriate. See Table 1 for description of subsamples. To establish the temporal order of events across study sites, mean recalled ages at menarche, first birth, last birth, tubal ligation (in Mexico), hysterectomy, and natural menopause were determined for each population. To further examine variation in the timing of these events, the number of years between age at menarche and age at first birth, age at last birth and age at natural menopause, age at last birth and tubal ligation, and age at tubal ligation and age at natural menopause were computed. We did not combine the three datasets for cross-population statistical analyses.

In all three sites (Campeche, Puebla, and Hilo), a structured questionnaire was administered to assess women's attitudes toward the menopausal transition; however, the questionnaires were not exactly the same, so cross-population comparisons of attitudes are limited. In Puebla, Mexico, the attitudes queried did not include a reference to fertility (Sievert and Espinosa-Hernandez 2003). Using data from Campeche and Hilo we were able to examine the relationship between questions associated, directly or indirectly, with fertility and age at interview, marital status, number of children, socioeconomic status index, as well as having undergone a tubal ligation (yes/no) or a hysterectomy (yes/no). All variables were also considered together in a logistic regression. We repeated the analyses with only pre- and peri-menopausal women, comparing attitudes related to fertility between women who had and had not undergone tubal ligation. Fisher's Exact 1-sided analyses were applied with the expectation that women with a history of tubal ligation or hysterectomy would be less likely to describe menopause as a loss of fertility. The logistic regression was also repeated.

Finally, in Campeche, Mexico, we examined all open-ended responses to the question "What is menopause?" We noted every instance of a participant explaining that menopause is the end of fertility, and then noted whether the participant had undergone a tubal ligation, hysterectomy, or both. We hypothesized that women who had undergone a tubal ligation would be less likely to describe menopause as the end of fertility.

Results

In Campeche, Mexico, mean age did not differ across the four sites, with an average of 47.4 (s.d. 4.9) years (n=543). Across the four sites, women attended 9.7 (s.d. 5.6) years of school, and women in the city had significantly more years of formal education (13.2 years) compared to the rural municipalities (4.2 years, $p < 0.001$). As shown in Table 1, women in the rural communities reported significantly higher parity ($p < 0.001$). There was no difference in menopausal status across sites, with 40.5% of the entire sample pre-menopausal (stages i and ii, as described above), 24.1% peri-menopausal (stages iii and iv), and 35.4% post-menopausal (stage v). Across the entire sample, 8.7% of women reported a history of hysterectomy, with a higher frequency among urban participants ($p = 0.05$). There was no difference across subgroups in the frequency of tubal ligations, with 50.6% of the entire sample reporting a history of tubal ligation (Table 1). Twenty-one women (4%) underwent both tubal ligation and hysterectomy. There were no differences in frequency of tubal ligation or hysterectomy by ethnicity (Maya vs. non-Maya, not shown).

	Campeche, Mexico N=543				Puebla Mexico N=755	Hilo, Hawaii N=793		
	City	Hopel- chén Norte	Calak- mul	Hopel- chén Sur	All	European- Am	Japanese- Am	Mix ed ethn icity
N	305	78	84	76	755	203	248	342
Mean age at interview (yrs) (S.D.)	47.5 (5.0)	47.4 (4.6)	47.3 (5.0)	47.1 (4.4)	50.0 (6.3)	*** 50.6 (5.2)	50.7 (5.0)	49.2 (5.1)
Parity range Mean (S.D.)	*** 0-7 2.0 (1.2)	0-11 4.1 (2.1)	0-17 5.1 (3.2)	1-12 5.1 (2.5)	0-15 3.6 (2.3)	*** 0-8 1.8 (1.5)	0-5 1.8 (1.0)	0-8 2.4 (1.4)
% post- menopausal	34.1%	35.9%	36.9%	38.2%	59.9%	45.2%	46.5%	42.4 %
% hysterecto my	* 11.5%	6.4%	6.0%	2.6%	23.1%	*** 12.2%	17.6%	25.3 %
% tubal ligation	50%	54.5%	52.4%	46.7%	42.5%	*** 35.2%	49.4%	60.0 %

Table 1: Sample characteristics. Comparisons across four subgroups within Campeche, and three subgroups within Hilo, Hawaii. * $p \leq 0.05$; *** $p \leq 0.001$

In Puebla, Mexico, women were on average 50 (s.d. 6.3) years of age, had 8.1 (s.d. 4.4) years of formal education, and reported 3.6 children. Almost 60% of the sample was post-menopausal, 23% had undergone a hysterectomy, 42.5% had undergone a tubal ligation, and 8% experienced both surgeries.

In Hilo, Hawaii, women were 50 (s.d. 5.2) years of age on average, with 2.1 children, and 43.7% of all women had a 4-year college degree or higher. Women of Japanese ethnicity had the highest level of education ($p < 0.001$). Across the sample, 48.1% were pre-menopausal (regular menses), 7.5% peri-menopausal (irregular menses and missed periods), and 44.4% post-menopausal (no menses within the past 12 months), with no differences in menopausal status across ethnic groups. Frequency of hysterectomy was 19.5%, and women of Mixed ethnicity were more likely to have had undergone the surgery ($p = 0.001$). Among all, 89.3% were still menstruating when the hysterectomy occurred. Half (50.3%) answered yes to the question "Have you been sterilized (tube's cut or tied)?" Women of Mixed ethnicity were more likely to have undergone sterilization ($p < 0.001$). Across the entire sample, 78 women (11%) underwent both tubal ligation and hysterectomy.

Table 2 compares mean recalled ages at menarche, first birth, last birth, tubal ligation, hysterectomy, and natural menopause across the three populations. Table 2 also shows the duration in years between the age at menarche and first birth, age at last birth and age at natural menopause, age at last birth and tubal ligation, and age at tubal ligation and natural menopause.

	Recalled age at menarche Mean (s.d.)	Age at first birth Mean (s.d.)	Age at last birth Mean (s.d.)	Age at tubal ligation Mean (s.d.)	Age at hysterectomy Mean (s.d.)	Recalled age at natural menopause ^a Mean (s.d.)
Campeche, Mexico	N=540	N=496*	N=499*	N=263	N=47	N=142
	12.4 (1.67) range 8-20 yrs	22.8 (5.71) range 9.9-44.9 yrs	31.2 (5.99) range 13.7-46.7 yrs	31.8 (5.18) range 20-46 yrs	40.4 (6.02) range 27-51 yrs	46.7 (4.32) range 35.0-57.6 yrs
Puebla, Mexico	N=745	N=697	N=697	N=292	N=161	N=259
	12.8 (1.61) range 7-18 yrs	22.7 (4.99) range 11.4-41.6 yrs	30.9 (5.70) range 16.0-46.6 yrs	33.0 (5.25) range 21-50 yrs	41.9 (6.19) range 25-58 yrs	47.1 (4.29) range 36-58 yrs
Hilo, Hawaii	N=777	N=681	N=672		N=104	N=219
	12.4 (1.64) range 8-18 yrs	25.1 (5.75) range 14-45 yrs	30.4 (5.57) range 17-47 yrs	n/a	39.6 (7.00) range 23-53 yrs	49.3 (3.59) range 36-57 yrs
	Years between age at menarche and first birth Mean (s.d.)	Years between age at last birth and natural menopause Mean (s.d.)	Years between age at last birth and tubal ligation Mean (s.d.)	Years between age at tubal ligation and natural menopause ^a Mean (s.d.)		
Campeche, Mexico	N=493	N=117	N=262	N=65		
	10.5 (6.04) range -3.11 ^b - 33.86 yrs	13.4 (7.41) Range -4.16 ^c - 30.25 yrs	1.1 (3.47) range -8.98 ^d - 21.95 yrs	15.4 (6.6) range 0.32-28.73 yrs		
Puebla, Mexico	N=688	N=236	N=293	N=88		
	9.9 (5.06) range -1.10 ^e - 28.75 yrs	15.0 (6.83) range -2.40 ^f - 30.60 yrs	2.2 (4.25) range -6.80 ^g -23.80 yrs	13.6 (6.31) range -2 ^h -29 yrs		
Hilo, Hawaii	N=673	N=155				
	12.7 (5.98) range -1 ⁱ -32 yrs	18.2 (6.02) Range 1-35 yrs	n/a	n/a		

Table 2: Recalled ages at menarche, first birth, last birth, tubal ligation, hysterectomy, natural menopause, and the duration of time between select events.

* Sample sizes vary because not all women had children or remembered their age at first or last birth.

^a Limited to menopause >35 years

^b Three women had negative durations. (1. urban): first birth at 10.9 years, menarche at 13. (2. rural Calakmul): first birth at 11.2 years, menarche at 12. (3. rural Hopelchén): first birth at 13.2 years, menarche at 15.

^c Two women had negative durations so that their last birth came after the age they gave for menopause. Participant #76C menopause 42.55, last child 46.72; Participant #42N menopause 39.77^g, last child 41.88. ^gwhen her menses started to diminish.

^d Nine women with negative durations of two years or longer (9/262 or 3.4%). Either incorrect ages were recorded or tubal ligations did not work. One woman gave details about how she was surprised by a pregnancy after her tubal ligation.

^e Two women had negative durations. (1) first birth at 15.9 years, menarche at 17. (2) first birth at 11.4 years, menarche at 12.

^f One woman had a negative duration. She reported a last menstrual period at 40.0 years, and last birth at 42.4 years.

^g Six with negative durations of two years or longer (6/293 or 2.0%). Either incorrect ages were recorded or tubal ligations did not work.

^h One woman reported her last menstrual period at 40, and a tubal ligation at 42.

ⁱ One women with a negative duration. (1) first birth at 16, menarche at 17.

Across the three populations, there was consistency in mean recalled age at menarche (12.4 to 12.8 years), as well as the youngest (7 or 8 years) and oldest ages (18 or 20 years) at first menstruation. In Mexico, there was a shorter duration between ages at menarche and ages at first birth compared to women in Hawaii. In all three populations a very small number of women reported giving birth before menarche (three in Campeche, two in Puebla, and one in Hilo).

Mean ages at first birth were earlier in Mexico compared to Hilo, but the oldest age at first birth was the same in Campeche as in Hilo (45 years). Mean ages at last birth were very similar across the three populations (30.4 to 31.2 years). The oldest age at last birth was the same (47 years) in all three populations. The time between age at last birth and age at natural menopause was shorter in Mexico compared to Hilo, and in both sites in Mexico a very small number of women reported giving birth after their menstruation ended (two in Campeche, one in Puebla).

Mean age at tubal ligation was a little earlier in Campeche (31.8 years) compared to Puebla, Mexico (33.0 years). In both sites mean ages at tubal ligation were within 1 or 2 years of the mean age at last birth. In both Campeche and Puebla, a number of women gave birth after having undergone a tubal ligation. In Campeche, 9 women (3.4%) reported births at least two years following a tubal ligation. In Puebla, 6 women (2.0%) gave birth at least two years following a tubal ligation (a two-year lag was used to avoid rounding errors in recalled ages at tubal ligation and/or last birth). Mexican women menstruated, on average, 15.4 years in Campeche and 13.6 years in Puebla between their tubal ligation and their age at natural menopause.

Mean age at hysterectomy was about the same in Campeche (40.4 years), Puebla (41.9 years) and Hilo (39.6 years). Mean recalled age at natural menopause was later in Hilo (49.3 years) compared to Puebla (47.1 years) and Campeche (46.7 years).

With regard to the end of fertility, in Campeche, Mexico, where the mean recalled age at menopause was 46.7 years, menopause was not the end of fertility for the 51% of women who underwent a tubal ligation at a mean age of 32 years and the 9% who reported a history of hysterectomy at a mean age of 40 years. In Puebla, Mexico, where the mean recalled age at menopause was 47.1 years, 43% of women did not *biologically* experience menopause as the end of fertility because they had undergone a tubal ligation at a mean age of 33 years, and 23% had a history of hysterectomy at a mean age of 42 years. In Hilo, Hawaii, where the mean recalled age at menopause was 49.3 years, menopause was not the end of fertility for half of the women, aged 40-60, who had undergone a tubal ligation and were already

unable to conceive. Almost one fifth of the women had undergone a hysterectomy at a mean age of 40 years and were unable to conceive.

Figure 2 illustrates how fertility ends early in women with tubal ligations (assuming that the tubal ligations are successful which, as Table 2 shows, is not always the case). The solid dark blue line indicates fertility between the onset of sexual activity (which is generally after menarche but, as Table 2 shows, not always) and tubal ligation. After tubal ligations, women continue to menstruate for an average of 15.4 years in Campeche and an average of 13.6 years in Puebla (Table 2). For these women, menopause is the end of menstruation, but menopause is not the end of fertility.

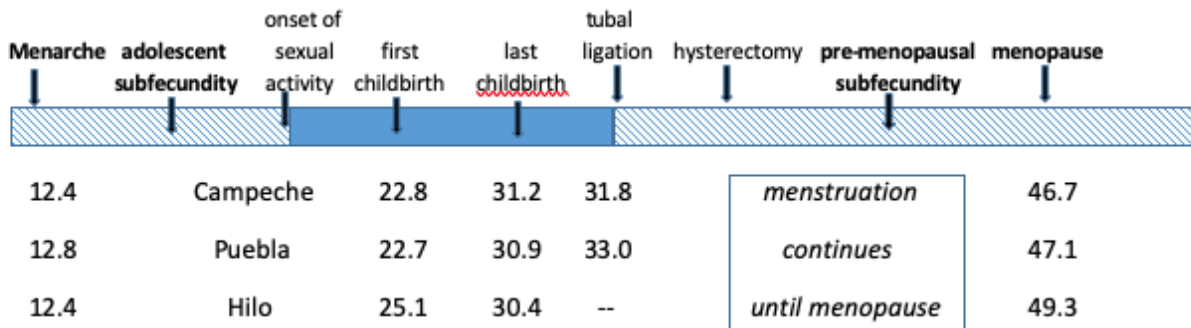


Figure 2: Tubal ligation as the end of fertility: timeline showing mean recalled ages (in years) at menarche, first childbirth, last childbirth, tubal ligation, and menopause in Campeche, Puebla, and Hilo. Dark blue indicates fertile period.

Figure 3 illustrates how fertility ends early with hysterectomies. The solid dark blue line indicates fertility between the onset of sexual activity and the hysterectomy. After the hysterectomy, women no longer menstruate, but if their ovaries are intact, then they continue to produce the hormones associated with fertility. They cannot, however, conceive. The hysterectomy marks both the end of menstruation and the end of fertility.

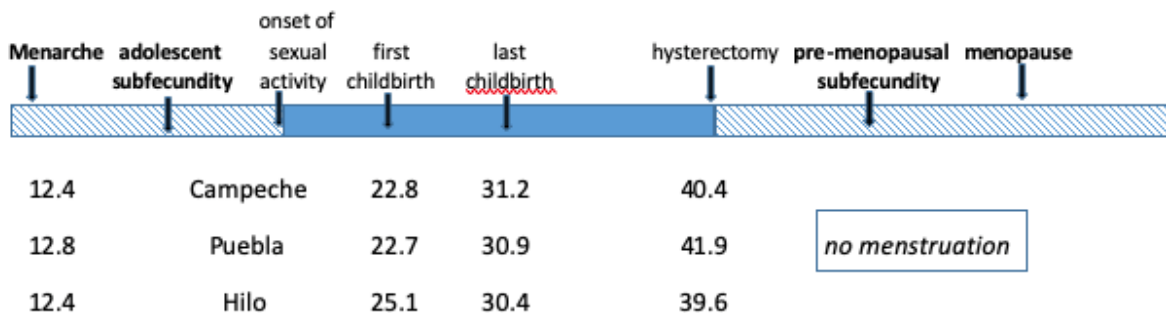


Figure 3: Hysterectomy as the end of fertility: timeline showing mean recalled ages (in years) at menarche, first childbirth, last childbirth, and hysterectomy in Campeche, Puebla, and Hilo. Dark blue indicates fertile period.

The results in the following sections address the question: Did women respond differently to questions about menopause if their ability to conceive ended prior to menopause due to tubal ligation or hysterectomy?

Campeche, Mexico

From a list of questions about menopause, 72.4% of participants agreed that it is “a liberation” to know that they were no longer at risk of pregnancy (n=214). The response was not associated with marital status, number of children, education, urban/rural residence, or socioeconomic status index but women who said “yes” were more likely to be older (mean 49.6 years vs. 46.8 years, $p=0.001$). Post-menopausal women were more likely to agree that menopause is a liberation (85%) compared to pre-menopausal (61%) and peri-menopausal (49%) women ($p<0.001$). There was no significant difference between post-menopausal women with or without hysterectomies (81.8% vs. 86.2%, $p=0.548$). Women with tubal ligations were more likely to agree compared to women without tubal ligations (77% vs. 68%), but the difference was not significant ($p=0.088$). Using logistic regression (results not reported here), post-menopausal status continued to be significantly associated with the opinion that menopause is “a liberation” after adjusting for age at interview, urban/rural residence, menopausal status, parity, marital status, education, and socioeconomic status. Women who had undergone a tubal ligation were significantly less likely to report menopause as “a liberation” (Odds Ratio 0.378, $p=0.008$).

In order to further test the hypothesis that having a tubal ligation changes a woman’s perception of menopause as the end of fertility, we examined this question about menopause as “a liberation” among women who were not yet post-menopausal. There was no significant difference between those with and without tubal ligations in the sentiment that menopause is a liberation from the risk of pregnancy (60% vs. 51%). Neither was tubal ligation significant when the logistic regression was repeated in this sub-group.

When asked if they thought menopause is an easier and more tranquil stage of life, 64.3% of the sample (n=403) said yes. This response did not differ in relation to marital status or socioeconomic status, but women who said “yes” were more likely to be older (mean 48.2 vs. 46.3 years, $p<0.001$) and tended to have more children (mean 2.9 vs. 2.5, $p=0.067$). Post-menopausal women were more likely to agree (78%) compared to pre-menopausal (57%) and peri-menopausal (55%) women ($p<0.001$). The difference was not significant for women with hysterectomies compared to women without hysterectomies (70.0% vs. 81.1%, $p=0.157$), or between women with and without tubal ligations (63.9% vs. 64.2%, $p=0.516$). The logistic regression showed that post-menopausal status, but no other variable, was associated with the opinion that menopause is an easier and more tranquil stage of life. In a repeat of the analyses among women who were not yet post-menopausal (n=351), those with and without tubal ligations did not differ in their response to this question.

Finally, 61.8% of the sample said that they can better enjoy sexual relations with their partner (n=173). In bivariate analyses, the response to this question was not statistically associated with age at interview, marital status, socioeconomic status, or number of children. There was no difference by pre- (72%), peri- (61%), or post- (59%) menopausal status ($p=0.348$) in relation to greater enjoyment of sexual relations. Neither was there a difference for women with hysterectomies compared to women without hysterectomies (69.0% vs. 55.0%, $p=0.191$), or between women with and without tubal ligations (67% vs. 58%, $p=0.136$). The same lack of significance was true in logistic regression results.

With regard to the open-ended question, “What is menopause?” most women described menopause as the end of menstruation, or the time when physical and/or emotional symptoms occur. In the city, but not in the rural communities, women talked about changes in hormones. Table 3 presents a sample of the open-ended responses associated with menopause as the end of fertility. The important point from Table 3 is that, in response to the open-ended question, very few women described menopause as the end of fertility. Women in the city were more likely to volunteer “the end of fertility or childbearing” when describing menopause, but even in the city only 29 of 305 respondents (9.5%) volunteered that

answer (see Table 3 for variation in the wording of open-ended responses). The percentage of women in the rural communities describing menopause as “the end of fertility or childbearing” was even lower: Calakmul 6%, Hopelchén Sur 1%, and Hopelchén Norte 0%.

Campeche city	Hopelchén Sur	Calakmul
A sample of the 29 responses describing menopause as the end of fertility. 29/305 = 9.5%	Only 1 participant described menopause as the end of fertility. 1/76 = 1.3%	Five participants described menopause as the end of fertility or productivity. 5/83 = 6%
<i>Periodo de receso de la reproducción femenina.</i> (A break from female reproduction.)	<i>Entiendo que ya terminó uno de tener hijos, ya no hay que preocuparse de embarazarse.</i> (I understand that we stop having babies, we don't have to worry about pregnancy)	<i>El doctor dice de la menopausia, que se siente bochorno, desesperación, es cuando una va a dejar de tener hijos... quedas otra vez como niña.</i>
<i>El cierre del ciclo de la mujer, que te dice tu cuerpo ya no vas a tener más hijos y viene una nueva etapa.</i> (The end of a woman's cycle that tells you that your body is not going to have more children and a new stage is coming.)		<i>(A doctor says about menopause, that one feels heat and desperation, it is when a woman stops having babies . . . they go back to be childlike)</i>
<i>Cierre del ciclo de la fertilidad de la mujer.</i> (The end of a woman's fertility.)		<i>Es un indicativo de que inicia la vejez y ya no hay más productividad de ella mujer. Ya caducó.</i>
<i>Cambios para que termine el ciclo productivo.</i> (Changes leading to the end of the reproductive cycle.)		<i>(It is a sign that old age is beginning and a woman stops being reproductive. It expires)</i>
<i>Cuando la mujer deja de ser fértil.</i> (When a woman stops being fertile.)		<i>Es el fin del ciclo reproductivo de la mujer en la edad adulta.</i>
<i>Etapa en la que se va a ir terminando el proceso de ovulación.</i> (The stage in which the end of the ovulation process starts.)		<i>(It is the end of the reproductive cycle of women in adulthood.)</i>
<i>Dejar de reglar, no se puede embarazar, termina ciclo reproductivo.</i> (Menstruation stops, cannot become pregnant, the end of the reproductive cycle.)		<i>El cuerpo de la mujer deja de "servir" porque ya no puede concebir.</i> (The woman's body stops being "useful" because it cannot get pregnant.)
<i>Es una etapa donde dejas de, tus óvulos y ovarios empiezan a envejecer como envejeces tú, y como que ellos ya, como que se secan, y tú ya no reglas, y no nada, envejeces como quien dice, tu aparato reproductor, ya que llega el momento en el deja de trabajar.</i> (It is a time when your eggs and ovaries start to get old, like you get old, and they		<i>La que escucho y la biblia dice: la menopausia es cuando ya no puede tener hijos, termina su periodo de reproducción.</i> (The one I listen to and the Bible says: menopause is when you can no longer have

shriveled, you stop menstruating and that's it; you and your reproductive organs grow old because it's time [for them] to stop working.)		children, your period of reproduction ends.)
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Table 3: Responses from three sites^a in the state of Campeche, Mexico, to the question, "What is menopause?" (*¿Qué es la menopausia?*). These are responses having to do with the end of fertility.

^aNo women in Hopelchén Norte described menopause as the end of fertility, 0/40

Hilo, Hawaii

When asked to choose words to describe menopause, 26.0% of the sample (n=719) chose the word "freedom." Women who chose "freedom" were more likely to be older ($p < 0.001$) and had fewer children (1.87 vs. 2.19, $p = 0.001$), but did not differ in marital status or level of economic comfort. Post-menopausal women (35%) were more likely to choose freedom compared to pre- (16%) or peri- (28%) menopausal women; there was no difference by hysterectomy or tubal ligation status. When all variables were entered into a logistic regression model (results not reported here), only parity was associated with the choice of "freedom," with an increasing number of children lowering the likelihood of selecting the word "freedom" to describe menopause (Odds ratio 0.812, $p = 0.007$).

"Onset of old age" was selected by 32.8% of the sample (n=719), with no difference by age at interview, marital status, parity, financial comfort, menopausal status, hysterectomy status, or history of tubal ligation in bivariate or logistic regression analyses.

"Loss of fertility" was selected by 23.1% of the sample (n=719) and did not differ by age at interview, marital status, parity, financial comfort, or menopausal status. However, consistent with our hypothesis, women who had undergone a hysterectomy were less likely to say that menopause was a loss of fertility compared to women who had not undergone a hysterectomy (17% vs. 24.1%, $p = 0.047$). Likewise, women who had undergone a tubal ligation were less likely to say that menopause was a loss of fertility compared to women who had not undergone a tubal ligation (20% vs. 26%, $p = 0.027$). After adjusting for the variables above, tubal ligation remained significant in the logistic regression model, with women who underwent sterilization almost half as likely to choose "loss of fertility" to describe menopause (OR 0.577, $p = 0.003$).

When a selection was made for women not yet post-menopausal (n=377), history of tubal ligation was not associated with "freedom" or "onset of old age," but continued to be associated with "loss of fertility." Women with a history of tubal ligation who had not yet reached menopause were less likely to describe menopause as a loss of fertility (19.5% vs. 27.1%, $p = 0.054$).

Discussion

This study examined events related to fertility among women aged 40 to 60 in three populations. The focus was on the timing of hysterectomies and tubal ligations, but a longer frame of reference was used to understand the chronology related to the "biological clock" of fertility (Figure 1).

There are social and economic differences across the three populations, but also important similarities. Only 12.4% of the population in the municipality of Calakmul, Campeche, Mexico, has access to running water (INEG 2015). Why, then, are the rates of tubal ligations so high? Although the municipality of

Calakmul lacks basic infrastructure, our pilot interviews in the community of Cristóbal Colón showed that women received health-related information from “physicians, workshops, public talks, and *caravanas de salud* (mobile health centers) that reinforce biomedical ideas and, most likely, the positive opinion and acceptance of the biomedical care that is available in this isolated site” (Huicochea 2017, 58). Most people living in the communities of Calakmul attend a primary care clinic run by the Mexican Social Security Institute (IMSS). There, an allopathic doctor and nurse are available 24 hours a day to provide medicine, vaccines, and a suite of complementary services for clinical and preventative care. During the 1970s and 1980s, in response to one of the highest population growth rates in the world, the IMSS created family planning campaigns to reduce risk due to unwanted pregnancies, provide better maternal care, create public awareness around family planning, and instill a sense of responsibility about the birth rate and its consequences in Mexico (Ramos de Viesca 2014, 159). The IMSS programs continue to focus on women’s and children’s health. Although Calakmul is isolated and lacks basic infrastructure, the theme of health is central to women’s lives, and women expressed confidence in biomedicine and regularly sought medical attention.

Although the state of Hawaii has been ranked as having the best health care system in the U.S. (U.S. News and World Report 2018), the research presented here was carried out in Hawaii County (the Big Island) where more than 20% of the East Hawaii residents live below poverty. The Native Hawaiian, Pacific Islander, and Filipino populations have the lowest levels of educational attainment and are most impacted by limited access to care and poor health outcomes (Belforte *et al.* 2013). Why, then, do those most impacted by limited access to care have the highest rates of hysterectomy and tubal ligation? It may be that tubal ligations and hysterectomies are a more expedient way of dealing with birth control and cervical dysplasia, uterine fibroids, or other concerns among women of Mixed ethnicity (Table 1) that include the Native Hawaiians and Pacific Islanders.

In an overview of the three studies, there were remarkable similarities across sites in many reproductive events, such as mean recalled age at menarche (12.4 to 12.8 years), mean age at last birth (30.4 to 31.2 years), and mean age at hysterectomy (39.6 to 41.9 years). There was more variation in mean age at first birth than mean age at last birth. It is striking that the oldest age in the range of age at last birth was the same (47 years) in all three populations.

In all three sites, menarche was not always the biological marker of fertility that we expected. Figures 1 and 2 represent the majority of women in our study, but there were a few exceptions. Three women in Campeche, two in Puebla, and one woman in Hilo reported ages at first birth that preceded their ages at menarche because the onset of sexual activity came before the first menstrual period. In the two Mexican sites, some births occurred after the age of tubal ligation.

In Campeche, nine women reported an age at tubal ligation that was two or more years earlier than the birth of their last child and, therefore, not the result of rounding error in ages at childbirth or tubal ligation. This rate of tubal ligation failure (9/255 or 3.5%) is possible, as the failure rate for tubal ligation surgery ranges from 7.5/1000 (0.8%) to 54.3/1000 (5.4%) depending on the type of procedure (Peterson *et al.* 1996). A study of pregnancies after tubal ligation in India found that tubal ligation failures were more likely after surgeries carried out in primary health centers, and were due to recanalization (up to 20 years after the procedure), improper surgery (e.g., operating only on the right or left side), and tuboperitoneal fistula (Date *et al.* 2014). In the population sampled here, one participant (a mother of 11 children) described, in detail, her surprise and dismay at being pregnant again after a tubal ligation.

Después que ella nació me hicieron mi salpingo, pero de repente a los dos años me sentí que estoy diferente, me da sueño, me da flojera, y digo “Dios mío, esto porqué, si a me tienen hecho la

salpingo”, agarro me acuesto y tallo ahí y siento una bolita ahí, Dios mío ¿y esto? ¿Será que estoy herniada?, será que algo me pasó, pero si yo tengo mi salpingo, no puede ser, no puede ser que estoy embarazada, agarro me fui con la Sra. que dicen que es muy buena, me talló, me dijo que estoy embarazada, le dije que no es cierto que me tienen hecho mi salpingo, y me dice “pues con todo y tu salpingo mamita, esto es embarazo, ni es hernia, si es hernia te lo digo, cuando te toco te va a doler, pero esto no, esto es embarazo”. Agarré y me fui con doctor en Campeche, le dije “usted me engañó me dijo que me había hecho mi salpingo y todo” me dijo que me hablaba con sinceridad y me dice que ellos no son Dios, somos hombres del mundo, pecado, nosotros hicimos tu salpingo, me saco todos los papeles, haita ahí lo hicimos todo, pero si las cosas no fueron como nosotros hicimos, quiere decir que nosotros no somos las que mandamos, la que manda es Dios, nuestro Dios sabe por qué te lo va a mandar este bebé.

After [my daughter] was born, they did my tubal ligation, but suddenly after two years I felt that I was different. I was tired, felt lazy, and I said, “My God, why this if I had my tubal ligation?” I lay down, touched my belly, and I felt a small ball there. My God, what is it? Am I herniated or did something happen to me? But since I had my tubal ligation I cannot be pregnant, it cannot be! So, I went with the lady that everyone says is very good. She touched me and told me that I was pregnant. I told her that was impossible because I had my tubes ligated and she said, “Despite your tubal ligation, mamita, you are pregnant not herniated; if you were herniated it would hurt you when I touch it but, no, this is a pregnancy.” So, I went to a doctor in Campeche and told him, “You lied to me, you told me you ligated my tubes and all.” He told me that, honestly, they [the doctors] are not God, just plain men; they did the tubal ligation. He showed me all the papers; they did it all. “But if things were not as we made them, it means that we are not in command. It was God’s command and He knows why He is sending you this baby.

Using the entire sample from Campeche, including post-menopausal women, participants with a history of tubal ligation were less likely to say that menopause was “a liberation” after controlling for demographic and reproductive variables. However, in contrast to our expectations, a history of hysterectomy or tubal ligation was not associated with the description of menopause as “a liberation” among pre- or peri-menopausal women. We were thinking of menopause as a liberation from concerns related to fertility, but perhaps the study participants were thinking about menopause as a liberation from menstruation. Women with tubal ligations continue to menstruate until menopause, so there is no reason to think that their answers would differ from women without a history of sterilization if menopause were considered a liberation from menstruation. Neither was a history of hysterectomy or tubal ligation associated with the description of menopause as “an easier and more tranquil stage of life.” It may be that midlife is filled with economic, familial, and emotional demands that extend beyond concerns specific to fertility (Sievert et al. 2018a, 2018b). Finally, a history of hysterectomy or tubal ligation was not associated with better enjoyment of sexual relations with a partner.

When we asked women in Campeche, “What is menopause?” very few women described menopause as the end of fertility or childbearing – 29 (9.5%) in the city (12 of whom had undergone a tubal ligation), five (6%) in the non-Maya rural communities of Calakmul (two of whom had undergone a tubal ligation) and only one participant in the Maya communities of Hopelchén. There was no indication among women in the state of Campeche – from either quantitative or qualitative responses – that individuals with a history of tubal ligation or hysterectomy were less likely to describe menopause as the end of fertility.

In Hilo, Hawaii, there was no relationship between a history of hysterectomy or tubal ligation and the word “freedom” or “onset of old age” to describe menopause. However, consistent with our expectations, women who had undergone a hysterectomy or tubal ligation were significantly less likely to say that menopause was a loss of fertility compared to women who had not undergone a hysterectomy or tubal ligation. After adjusting for demographic and reproductive variables, women with a history of tubal ligation were almost half as likely to choose “loss of fertility” to describe menopause.

On the basis of qualitative interviews with 45 peri- or postmenopausal midwestern U.S. women aged 38 to 60 years, Dillaway (2005) suggested that the use of any contraceptive – not just sterilization – “makes menopause an insignificant marker in some women’s lives, because menopause no longer represents a symbolic end of fertility” (404). She noted that most of her study participants and their partners actively avoided pregnancy long before the onset of reproductive aging. Consistent with our findings (Figures 2 and 3), reproductive capacity was confined to a period of time much shorter than the span determined by menarche and menopause.

One of Dillaway’s participants explained, “I think people should go through menopause early. . . . I had my tubes tied when I was 35. So that I knew, you know, from the time I was 35 until 52 I could still have sex and not get pregnant. So [menopause] meant nothing to me” (Dillaway 2005, 407). Unlike Dillaway’s midwestern U.S. sample, it may be that women in Campeche do not have the same level of trust in the efficacy of tubal ligations, and so did not demonstrate a difference in their attitudes toward menopause in relation to their history of tubal ligation.

Future researchers could examine the high rates of hysterectomies and tubal ligations in Mexico and the U.S. in relation to attitudes held by health care workers. For example, a study among U.S. and Mexican college students found a significant positive correlation between scores for hostile sexism and negative attitudes toward women with hysterectomies among Mexican male students (Chrisler *et al.* 2013). Access to tubal ligations is also shaped by gender relationships in which men may resist giving permission to their wives or partners to curtail childbearing (Castellar *et al.* 2003). Future work could also examine attitudes of women themselves (Reyes and Rosenberg 2019) or the role of the culture of biomedicine (McCallum 2005) or governments (Smith-Oka 2009) in shaping high rates of hysterectomies and female sterilization. From a political economic perspective, Smith-Oka (2009) suggests that contraception has been used as a means to modernize Mexico. Her ethnographic work among the Nahua of northern Veracruz, Mexico, showed how cash transfer policies that encourage the use of medical services (e.g., *Oportunidades*) may result in women feeling coerced into having smaller families and undergoing certain procedures, such as sterilizations (Smith-Oka 2009). Future work should also delve into potential ambivalence associated with the biotechnology of contraception and the nature of women’s roles (Roberts 2016). As has been shown among men’s choices about the use of medicine to manage erectile difficulties with age (Wentzell 2013), it may be that women’s attitudes, and potential ambivalence about both fertility and the biotechnology of sterilization, shape decisions about undergoing tubal ligations and/or hysterectomies.

We expected that ideas about menopause would be contingent on past biomedical experience with tubal ligations and hysterectomies. What we encountered among women in their 40s and 50s was evidence that menopause serves as a marker for the end of menstruation, but that menopause is not an important marker for the end of fertility. Women who were still pre-menopausal did not indicate, through questions and answers about menopause, that tubal ligations had already ended their childbearing. Perhaps, particularly in Mexico, this is because of the failure rate of those “permanent” methods of sterilization. The effect of other contraception methods that are imperfect (condoms, IUDs, birth control

pills) may have even less influence on women's perception of menopause. The loss of fertility is real, imagined, and "local" (Lock 1993), and the truncation of fertility by sterilization through tubal ligation may not be understood in the same way as the loss of fertility signaled by the cessation of menstrual blood. Future work should consider how the concepts of "chronologization," or "standardization" of the life course (Brückner and Mayer 2005; Emonds 2014; Kohli and Meyer 1986) can be further applied to understand the timing of the biological, behavioral, and medical events potentially associated with fertility and the "biological clock."

There are some limitations to the study. We asked questions about menopause, but not about the end of fertility, and those two things are not synonymous. We missed the opportunity to ask women about their feelings about their own fertility. Perhaps, after a tubal ligation, women still *feel* fertile in the sense of investing in children, tending to grandchildren, and perhaps menopause is a visible reminder to a woman that she can no longer bear children of her own. If we were to repeat this study, we might ask women to describe when their fertility began and when it ends.

The three datasets were not merged to test for statistically significant differences. This is because the questionnaires were similar but not exactly the same. For example, in Hilo, Hawaii, women were asked "How old were you at the birth of your first child? your last child?" In Puebla and Campeche, women were asked for the actual dates of their first and last childbirths. In Hilo, we asked about levels of financial comfort (e.g., "struggling," "OK," "well-off"), whereas in Campeche we constructed a socioeconomic index based on materials used in house construction and other variables. In Hilo and Campeche, women were asked specifically about whether menopause was seen as an end to fertility among other conceptions of menopause, while in Puebla, reliance was placed on an open-ended question about the meaning of menopause. In the study presented here we report recalled ages at menopause for comparison, but those ages are subject to error in recall as well as truncation toward an earlier age than the median computed by probit (Sievert and Hautaniemi 2003; Sievert *et al.* 2013). In addition, we did not make use of all of the qualitative data collected in Campeche. Instead, we chose just one of the questions that assessed women's understanding of the meaning of menopause. This partial utilization of the data might limit the scope of the analyses presented here. The data will be studied more closely utilizing an ethnographic lens in the future.

It is also important to point out that our thinking has been somewhat unidirectional in the sense that we considered attitudes towards menopause and the loss of fertility only *after* the experience of hysterectomy and/or tubal ligation. It may be that attitudes toward fertility and aging were among the factors contributing to the high rates of tubal ligation. Given the cross-sectional nature of these data, we cannot reconstruct attitudes prior to sterilization, but this is something to be considered in the future.

In summary, tubal ligations were experienced by half of the women in Campeche and Hilo and by just under half of the women of Puebla. Hysterectomies were experienced by 9% to 23% of the women across the three locations. At least half of the women across these three populations curtailed their fertility years (sometimes decades) prior to menopause. We did not show that a history of tubal ligation or hysterectomy was associated with attitudes toward menopause in Campeche among pre- or perimenopausal women. In Hilo, women with a history of tubal ligation were almost half as likely to choose "loss of fertility" to describe menopause compared to women who had not undergone a tubal ligation. Remarkably, there were numerous similarities in women's reproductive life histories and attitudes toward menopause despite the cultural and geographic differences. Women's attitudes toward fertility, and subsequently end of fertility, are complex and may be influenced, in part, by a pervasive biomedical model in all three sites.

Note

1. Here, “fertility” is used to mean the capacity to reproduce, what demographers preferentially define as “fecundity.”

Acknowledgements

This study was funded by NSF Grant #BCS-1156368, NSF Grant # 9805299, and NIH grant No. S06-GM08073-32. We are indebted to Lourdes Cahuich as well as the women and authorities of Campeche, Ich Ek, Suc Tuc, Ukum, Xmabén, Xhanha, Chunchintok, Cristóbal Colón, Ricardo Payro, Narciso Mendoza, and Ley de Fomento Agrario. Likewise, we thank the medical staff of Ricardo Payró, Ich Ek, and Cristóbal Colón. Finally, we thank Brenda Araujo, Shoshana Berenzon Gorn, Leydi Cen, Isai Delgado, Gía del Pino, Natalia Dzul Martín, Raquel Dzul Martín, Elizabeth Dzul Martín, Zayda González, Guadalupe Islas Monter, Lizbeth de las Mercedes Rodríguez, María Magdalena Montaña Barbano, Alejandra Mosqueda, Giselle O’Connor, Elena Pasqual, Alba Valdéz Tah, Ingrid Vargas Huicochea, and Adela Velazco.

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