Another Science War:
Fictitious evidence on women's fertility and the "egg aging" panic in 2010s Japan

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Abstract

Purpose: In the early 2010s, Japanese society recognized and experienced a panic about increasing infertility and people's lack of knowledge about human reproduction. This paper focuses on several graphs that misrepresented or distorted scientific findings that were used in the campaign related to this panic and explores (1) how the graphs were made, used, and authorized, and (2) how they contributed to changes in discourses and policies.

Methodology/approach: Literature survey.

Findings: (1) The graphs were made in the field of obstetrics, gynecology, and reproductive medicine by questionable methods, including falsifying, trimming, and misunderstanding of data. (2) Researchers in the field of fertility study relied on secondary and tertiary sources thus ignoring and compounding errors. (3) Such inauthentic research was approved and politically mobilized by professional organizations, rather than being penalized or criticized. (4) Discourse based on such unscientific knowledge may have encouraged a pronatalist policy of promoting early marriage and education about human fertility and life planning, targeted at teenage girls.

Research limitations/implications: Any society suffering from a low birthrate can experience similar phenomena. This study focuses on Japan, but it has wider implications about how low integrity and quality of the presentation of medical research can cause these issues elsewhere in the world.

Social implications: This paper includes a warning against biological explanations that contain unscientific connotations about gender.

Originality/value of paper: This paper confirms how gender-related policy in 2010s Japan was influenced by science that lacked research integrity and was of sub-standard quality.

Keywords: pseudoscience, reproductive medicine, pronatalist policy, fecundity, biology, education

Aim and Scope

Even with highly advanced reproductive medicine today, assisted reproductive technology is not necessarily successful. This is especially true of women who are advanced in age. As this fact has become known, medical authorities have gained influence over fertility issues, particularly in societies with advancing maternal ages and low birthrate levels. Experts in medicine, epidemiology, and health education have emphasized the importance of knowledge about the effects of age on fertility.

As is often the case in popularized medical discourses, age-related fertility decline is explained to general audiences in oversimplified ways. The terms "biological clock" and "egg aging" are frequently used in such discourses to explain why fertility declines with age. In addition to such metaphorical phrases, medical professionals have been known to use unscientific visual representations to substantiate their claims.

Fig. 1 displays well-known data indicating a linear decline in female fertility as age advances. That downward curve, often titled "Likelihood of getting pregnant," always appears in a graph along with an upward curve indicating the proportion of sterility (Tanaka, 2016c). This kind of graph is widespread among so-called fertility sites on the Internet. It emphasizes the negative effects of age on fertility and may thereby create pressure for young girls to have a child in their early 20s.

[Take in Figure 1]

The downward curve in Fig. 1 is derived from data published by Carcio (1998, p. 38) and Rosenthal (1998, p. 5), but the data has no scientific grounding (Tanaka 2016c). Rosenthal (1998) offers a misleading label of "Likelihood of Getting Pregnant" to figures that do not in fact indicate the likelihood of a person getting pregnant. Carcio (1998) offers no information about the source of her data.

With regard to such inappropriate use of unscientific data, Japan's is an extreme case. The egg aging campaign started in 2011 on Japanese mass media, and soon dominated the public conversation. The rapid spread of the discourse was supported by a number of faulty graphs. Medical professionals and academic associations provided and authorized these graphs, and played an important role in introducing them into the government's policy-making process.

In this chapter, I will describe how professionals created and authorized unscientific graphs and how they were effective in their media campaign and in affecting government policy-making. I will thereby discuss the social construction of "scientific" knowledge and its legitimacy. The social legitimacy of science is based on the consensus that scientists conduct scientific research scrupulously in order to provide useful results that offer insight into the character of natural laws. However, if it is proved that scientists are fabricating and broadcasting unscientific knowledge, can we discard this consensus? Moreover, how is it possible to fight against such unscientific science? This paper also outlines the historical context in which "scientific" knowledge about women's bodies was introduced during a period of backlash against gender-mainstreaming. It is therefore a case report about an aspect of so-called "science wars" (Ross, 1996): the mobilization of science as an instrument to be used against movements promoting the rights of minorities.

History of Discourses about Women's Age and Fertility

Discourses about age and fertility in the mid-20th century

Discourse about the relationship between women's age and their fertility had already appeared by the early 1940s in Japan. As a countermeasure to the reduced birthrate after the beginning of the Second Sino-Japanese War in 1937, the Empire of Japan established the Institute of Population Problems (now the National Institute of Population and Social Security Research: IPSS) in 1939. One of the missions of

the Institute was to conduct the first National Fertility Survey in 1940 to find evidence for the government's pronatalist policies. This survey (Nakagawa & Koyama 1941) found that there was a negative relationship between the cumulative number of children per couple and the wife's age at marriage. While wives married at the age of 17 had an average of 6.24 childbirths, the number linearly decreased as the age at which women married advanced. Only one child could be expected to be borne by a wife married at the age of 36. These findings were used to justify the government's policy of encouraging early marriage, with the idea that lowering the age of marriage by three years from 24 to 21 would result in an average of five children per couple (Schoppa, 2008).

Biological fertility decline was not regarded as a strong factor in this demographic discourse, although Nakagawa & Koyama (1941) reported an age-related decline in fertility. The negative effect of late marriages on the number of children was mainly explained as a function of the length of a woman's reproductive span, which begins with marriage and ends with menopause. This explanation is mathematically demonstrable, as follows. A one-year delay of marriage reduces the number of children by the marital fertility rate at that age. That figure was about 0.3 in the early 20s, an age span before which most women married in those days. In comparison, age-related fertility decline occurs at a slow pace, at less than 0.01 per year (Nakagawa & Koyama, 1941, pp. 10–14). The effect of the declining fertility of wives is therefore a minor factor.

The pronatalist campaign in the 1940s was not fruitful. Japan soon entered a period of general mobilization leading up to the Asia-Pacific War, in which it experienced defeat in 1945. With the exception of a postwar baby boom from 1947 to 1949, Japan subsequently witnessed a long-term decline in birthrates. Statistics show a below-replacement-level of fertility for women born in 1932 (IPSS, 2003, Table 4-10). After a standstill over successive cohorts, there has been a trend of declining fertility for women born in 1950 and later (IPSS, 2016a, Table 4-11).

Fertility issues and gender-mainstreaming in the late 20th century

The declining birthrate was again seen as a social problem in 1990, although this trend had been observed by demographers prior to this time (Schoppa, 2008). It was accompanied by discourses about delaying marriage and growing rates of unmarried adults. As demographic studies revealed that there was little decline in marital fertility and that out-of-wedlock births were rare, the decline in the birthrate was thought to be due to changes in people's marriage patterns (Senda 2015).

The 1990s was also a decade of increased gender equality. After the ratification of the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW) in 1985, the government of Japan made efforts to promote gender equality. The Equal Employment Opportunity Law was enforced in 1986 (amendment of Law No. 113 of 1972), and general childcare leave was instituted in 1991 (Law No. 76). In addition, the government aimed at expanding public daycare for infants in the 1994 Angel Plan (Coleman, 2008). Further, the Basic Law for a Gender Equal Society in 1999 (Law No. 78) made the government responsible for promoting gender equality. This law provided that the Cabinet should arrange the Basic Plan for Gender Equality and revise it every five years.

Work-family reconciliation was one of the main focuses of the political movement toward gender equality. It was also recognized as an effective countermeasure against declining birthrates, following the assumption that the difficulty of women pursuing careers after marriage was a major cause of delays in marriage and thereby significantly responsible for the decline in birthrate (Coleman, 2008).

Despite these policies, Japan's birthrate continued to decline. In 2005, the country's total fertility rate (TFR) dropped to 1.26, the lowest record in the history of Japanese birthrate statistics (IPSS, 2016a, Table 4-9). This result is understandable, because the policies were not effective in reducing the work-family burden. Even today, most women quit their jobs due to marriage, pregnancy, childbirth, or childrearing (IPSS, 2016b, Table II-4). Public daycare centers admit only 30–40% of infants aged one or two years old (IPSS, 2016b, Table II-4-8), and have almost no capacity to accommodate more children. To be sure, Japan's gender-equal policy improved some aspects of gender relations, especially

in prohibiting discrimination and harassment in workplaces. However, it was not successful in changing the life course established by the gendered roles of male breadwinner and female caretaker (Suzuki F. & Tanaka, 2013).

Backlash and introduction of biological explanation

In the early 2000s, the Japanese gender-equal movement and policies were under attack from the country's right-wing politicians (Seok, 2014). One of the targets most harshly attacked in this backlash was the concept of gender as a social construction, a formulation that had been featured in an official document, *Vision of Gender Equality* (Council for Gender Equality, 1996), prepared in the process of establishing the national machinery for gender equality. As a result of this counter movement, which emphasized the social order of sex roles based on biological differences, gender-equal policies were pushed back. Accordingly, in 2005, the second Basic Plan for Gender Equality included a sentence claiming that masculinity and femininity should be maintained and that Japan's traditional culture and family systems should be supported. Its following two revisions in 2010 and 2015 incorporate these concepts stating that gender equality should be founded on understandings of biological differences between sexes (Tanaka, 2016a).

Following these changes, Japan's population issues entered into their next stage, in which population policy became independent of gender policy and incorporated a medical perspective. The Basic Law for Measures to Cope with Society with Declining Birthrate (Law No. 133 of 2003) declared a national priority to raise the country's birthrate. Article 13 of this law makes it the responsibility of the central and local governments to promote maternity health care and infertility treatment. The Cabinet determined the outline for administration based on this law. The law and the administration outline thus included medical perspectives in the development of population policy.

In line with the medicalization of population policy, the Health and Global Policy Institute (2005) published a report on women's healthcare with the aim of raising the national birthrate. Page 19 of this report displayed a graph adapted from Heffner (2004). Fig. 2 is taken from the original data[1] of the graph. This curve displays an average pattern of age-specific marital fertility rate (ASMFR) from ten "natural fertility" populations, mainly based on historical records from Europe, Africa, Asia, and North America from the 16th to 20th centuries (we will revisit these data in the discussion of Fig. 4). "Natural fertility" is a demographic term used to denote the fact that people do not deliberately control the number of children they have (Henry, 1961). Heffner (2004) and the Health and Global Policy Institute (2005) consider ASMFR under natural fertility as indicating women's biological fertility at the age.

[Take in Figure 2]

Note that the curve shows a round shape. Women's fertility is at its maximum when they are in their early 20s, after which it decreases; however, the decrease is not large until women reach their mid-30s (Fig. 2). This means that an advancing maternal age will not have a large impact on fertility as long as most women complete their reproduction by their mid-30s. According to estimations by Senda (2015) based on the same data used in Fig. 2 and some additional assumptions, the decrease in complete fertility rate in Japan was mainly due to the decrease of unprotected intercourse. To be sure, the statistics suggest an increase in the number of women who cannot have children in spite of their efforts to conceive, due to the lowered biological fertility in their 30s and 40s. However, this effect is marginal; the primary factor of the birthrate decline is that an increasing number of people give up or do not want to have children, even though they are biologically fertile.[2]

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[1] Heffner (2004, p. 1927) plotted slightly higher values than the original, although the overall shape is similar.

[2] Senda (2015, p. 10) evaluates her estimation as "very simple and rough" in consideration of its naive assumptions. What is important here is that the estimation of the impact of delaying maternal age depends on the assumed shape of an age-fertility curve.

The "egg aging" panic

In the 2010s, public discourse shifted towards an emphasis on biological explanations for age-related decline in fertility. "Ransi (no) rouka" (egg aging) is a phrase frequently used in such discourses to symbolize the underlying biological determinants of women's fertility. Originally it referred to the degeneration of an ovum or oocyte owing to a long delay in the process of meiotic division (Suzuki S., 1979). As the concept gained popularity, it began to be used without a precise understanding of the biological mechanisms it describes. Further, this concept is often mixed up with the findings that human oocytes are generated at the fetus period—before birth—and then continue to decrease in number (NHK 2013). It is also incorporated with reports that infertility treatment often fails with unidentified cause when the female patient is advanced in age (Kawai, 2015). In Japanese, the specific biological term for ovum is "ransi." In this paper, however, I translate it as "egg" in order to represent the broad connotation the phrase has taken on as a symbol of the invisible determinants of age-related declines in fertility.

The concept of egg aging started to be featured in Japanese magazines in 2011 (Kodansha 2011). The phrase then gained explosive popularity in 2012, especially through TV-programs by NHK (Japan Broadcasting Corporation) about infertility issues (NHK 2013). These TV-programs aroused public attention about infertility. Along with the fact that, in the early 2010s, the maternal age had been advancing and the average age at first childbirth was around 30 years old, the new biological knowledge about "egg aging" was shocking to people. Many came to believe that they had thoughtlessly postponed childbirth, and consequently would miss the opportunity to have children. This idea directly justified the political movement to educate people on egg aging, which encouraged women to become pregnant earlier in life.

These media campaigns and political movements lacked a level of self-reflection, and it is for this reason that I call the phenomenon a "panic." Many professionals appeared on TV-programs and magazines, wrote books and Web articles, and offered their opinions on the subject to the government. However, the evidences supporting their opinions were not subjected to scrutiny. This resulted in the spreading of unscientific graphic presentations that exaggerated the influence of age in the decline of women's fertility, as we will discuss in the next section.

Establishment of self-image as a society without sufficient knowledge about human fertility

The egg aging campaign in Japan was triggered by an exaggerated interpretation of unreliable results from a cross-national survey, the International Fertility Decision-Making Study (IFDMS), conducted by a Cardiff University research group in 2009–2010. According to the results of IFDMS (Bunting, Tsibulsky, & Boivin, 2013), respondents in Japan exhibited a low level of fertility awareness (the second lowest among the 18 countries surveyed) measured with Cardiff Fertility Knowledge Scale (CFKS). As this result was featured in popular magazines, books, and TV-programs, it was widely accepted that Japanese have incorrect or distorted knowledge about pregnancy and childbirth (Fassbender, 2016).

Today it is known that IFDMS was a low-quality survey, and that its results are unreliable. Tanaka (2016b, in press) points out the following problems in IFDMS. (1) The samples could not be compared among countries. (2) Questionnaires were not pre-tested. (3) The translation process was not sufficient to ensure comparability among languages. (4) The Japanese version of the questionnaire includes many unnatural Japanese phrases, as well as spelling errors. (5) The questionnaire for men includes questions asking the respondent's thoughts about why he is not pregnant. (6) At least 10 of the 13 items of the CFKS were improperly translated. (7) Different ordering of the items of the CFKS between the English and Japanese versions may result in different responses. (8) The score of CFKS shows low statistical reliability for some countries. (9) The study is not replicable because the questionnaires are not available.

However, before such criticism first appeared in September 2015 (Takahashi S., 2015), results from

IFDMS had established it as a main source of the low levels of fertility-related knowledge in Japan. In February 2011, Professor Jacky Boivin, the representative researcher of IFDMS, talked about the results of the research to the Diet members and to mass media in Tokyo (Boivin, 2011; Miura, 2011). She also appeared on the magazine (Kodansha, 2011) and TV-programs (NHK 2013) mentioned above. The Japan Association of Obstetricians and Gynecologists (JAOG) repeatedly featured the IFDMS results for their monthly press conferences (Kuribayashi, 2014) and their newsletter (Kinoshita, 2015). IFDMS thus facilitated the establishment of Japan's self-image as a society lacking knowledge about human fertility.

IFDMS also affected governmental policy. Noda Seiko, a member of the House of Representatives, introduced the findings of IFDMS in the Diet in 2012 as evidence of Japan's low fertility awareness (Tanaka, in press). Saito Hidekazu, doctor at the National Center for Child Health and Development, used figures from Bunting et al. (2013) in presentations at government conferences for policy-making about population issues (Cabinet Office, 2014; Saito, 2014b, 2015).[3] In March 20, 2015, the government (the Third Abe Cabinet) determined the new administration outline for policies targeting low birthrates (Cabinet Office, 2015), one of whose pillars was improved education about fertility. According to the appendix of the outline, the government made it a goal to raise understanding of scientifically and medically correct knowledge about pregnancy and childbirth to 70% by 2020, up from 34% in 2009.[4] The outline also included measures to encourage early marriage and pregnancy, through collaboration with municipalities, schools, and companies.

The 2015 new pronatalist policy

Following the new administration's outline in 2015, the government initiated a number of policies to promote marriage and pregnancy. "Life planning" is a key phrase for these policies. Young people are encouraged to make a life plan including marriage, children, and other family issues, in addition to the development of their education and jobs. Various kinds of activities are conducted with national subsidization to arrange a suitable match for those who seek potential marriage partners, and lectures and textbooks are prepared for youths to help guide their choices (Fassbender, 2016; Nishiyama & Tsuge, in press). Knowledge about fertility is identified as an important resource for making the best decisions about the timing of marriage and pregnancy.

In August 2015, as part of this initiative, the government distributed a supplementary health education textbook that focused on family planning to all high schools in Japan. However, it triggered criticism against the government's policies. The mass media reported that the supplementary textbook included a graph on the relationship between women's age and their likelihood of getting pregnant (see Fig. 5a) and that the graph featured a curve greatly different from that found in the paper from which it borrowed (Mainichi Shinbun, 2015). Researchers then started to investigate materials used in the egg aging campaign and found a number of other dubious graphs. Some of these will be discussed in the following section.

The new pronatalist policy also introduced the numerical goal of raising Japan's TFR up to 1.8, in order to keep the national population size over a hundred million. This figure was not included in the administration's outline (Cabinet Office, 2015), but it was made public at the press conference on September 24, 2015 by the Prime Minister Abe Shinzo, as one of the set of economic policy goals called "new three arrows" (Cabinet Secretariat, 2016).

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[3] Saito acknowledged mistranslations in the Japanese IFDMS questionnaire (Goninkatsu, 2014). It is therefore evident that Saito deliberately broadcasted the unreliable research result.

[4] The appendix of the administration outline states that the figure of "34%" was based on Bunting et al. (2013), but this figure is not found in their paper. Bunting et al. (2013, p. 392) indicate the score (CFKS) for Japan as 37 or 38 (Tanaka, in press).

Graphical Representation to Arouse Public Attention

This section introduces three faulty graphs that exaggerate the influence of age in the decline of women's fertility. As far as I know, the first appearance of these graphs in Japanese non-professional publications was Fig. 3a in March 2012 (Saito & Shirakawa, 2012, p. 27). Fig. 4a first appeared on a webpage dated April 2013 (JSRM, 2013). Fig. 5a first appeared on a webpage dated June 2013 (Yoshimura, 2013). These graphs circulated in Japan over a short period of one or two years, during which the egg aging panic prevailed.

Undocumented Bayesian estimates of daily fecundability by Dunson et al. (2002)

Fig. 3a, replicated from Dunson, Colombo, & Baird (2002), shows the estimated probability of conception for each day of the month (relative to the day of ovulation) for women aged 19–26, 27–34, and 35–39 with partners of the same age or five years older. This estimation is based on a study of seven family planning centers in Europe from 1992 to 1996. Data were collected using a self-administrated diary of intercourses, basal body temperatures, and other factors (Colombo & Masarotto, 2000).

[Take in Figure 3]

The graph is characterized by sharp peaks in the curves at two days prior to ovulation, and creates the impression of a rapid decrease in the probability of conception by age, owing to the obvious difference between the high peak for younger age groups and the low peak for older age groups. Referring to Dunson et al. (2002), Kawai (2013) stated that the fertility of women in their late 30s is about one-half of that for women who are around 20 years old. Saito (2015) also used this depiction in governmental conferences to create the impression that fertility declines with age, with red arrows decorating it to emphasize the differences among the peaks.

This impression is exaggerated. If you notice the points other than those at the peak, you will find that there is actually not a great difference in fertility among age groups. Indeed, Dunson, Baird, & Colombo (2004) reported the estimates of yearly probability of conception (under the assumption of two acts of intercourse per week), using the same European multicenter study data, that the probability of conception for women aged 35–39 will be about 90% of that of women aged 19–26. Fig. 3a is therefore not evidence of a great decline of fertility for women in their late 30s.

Additionally, Dunson et al. (2002) has a fatal defect in that it does not specify the methods used to determine its figures. It explains Fig. 3a as the result of a Bayesian estimation, but it does not include enough information to specify the model and prior distribution. In particular, there is almost no information about prior distribution, even in the paper (Wilcox, Weinberg, & Baird, 1998) Dunson et al. (2002) refers to as the source of its values.

As for the statistical model used by Dunson et al. (2002), some information is found in Dunson's study (2001). According to Dunson (2001), the model is a modified version of a formula by Schwartz, McDonald, & Heuchel (1980). The original formula (Schwartz et al., 1980) is a multiplicative function to distinguish the probability of conception for each day if multiple intercourses occur during a menstrual cycle. Colombo & Masarotto (2000) developed an estimation based on this formula with the same data as Dunson et al. (2002). Their estimation shows no salient peak and no statistically significant differences among age classes[5] (Fig 3b). Colombo & Masarotto (2000, Tables 7, 8) also report the results for the data of menstrual cycles with single intercourse during the days when conception can occur, where the probability can be determined straightforwardly, without reference to the formula of Schwartz et al. (1980). The results of this calculation show no salient peak.

The differences between Fig. 3a and 3b are the result of differences between the statistical models used in the two studies. Dunson (2001, p. 1068) modifies the formula of Schwartz et al. (1980) to give a

[5] The age classification slightly differs between Fig. 3a and 3b.

special treatment for the "most fertile day" (MFD). This modification implies that (1) the probability of conception will be estimated as especially high for the MFD, and (2) the estimated probability for MFD will be even higher if conception occurs in a menstrual cycle with intercourses on both the MFD and another day. It is probable that the MFD corresponds to the peak two days before the ovulation in Fig. 3a. It is also probable that the peak is higher for younger ages because young couples frequently have intercourse and are therefore more likely to have intercourse on both the MFD and another day. Thus, peaks in Fig. 3a may be the artificial result of arbitrary modeling by Dunson (2001). These are, however, my inferences, and there is no concrete grounds for associating the MFDs with the peaks in Fig. 3a, because Dunson et al. (2002) provides no explanation for why this would be the case. Anyway, the results from Dunson et al. (2002) do not fit to the data as mentioned above.

Perhaps even more embarrassing, these problems have not been discussed by researchers in the field of fertility study. I confirmed this using citation indexes (with *Web of Science* in January 5, 2017). While Dunson et al. (2002) has been cited 194 times, Dunson (2001) has been cited 21 times. Among these 21 works, 11 cite Dunson et al. (2002), but 7 of them are self-citations by the author(s) of Dunson et al. (2002). Excluding these self-citations, only four works (Ecochard, 2006; Lynch, Jackson, & Louis, 2006; Mikolajczyk & Stanford, 2006; Zhou, 2006) remain, none of which offer a discussion about the validity of the statistical model. In sum, Dunson et al. (2002) has been referred to without scrutiny of its methods. Despite this lack of critical consideration on its validity, the graph from their paper has been used as if it were scientific evidence that fertility rapidly decreases with age.

Trimmed natural fertility curves by JSRM (2014)

The Japan Society for Reproductive Medicine (JSRM, 2014) published a standard textbook for training doctors in reproductive medicine; this featured a graph showing four age-fertility curves. The book does not specifically name the author of the graph, but the author is likely to be Takahashi Toshifumi, now a professor at Fukushima Medical University, who wrote a chapter in a separate book (Takahashi T., 2014) that included the same graph. There are also some versions of the graph on websites[6] designed for a general audience. Fig. 4a is adapted from a version of the graph found in an online magazine (Tarui, 2014); its curves and captions are identical to those published by JSRM (2013, 2014) and Takahashi T. (2014).

[Take in Figure 4]

JSRM (2014) explains that the curves indicate typical cases taken from Menken, Trussell, & Larsen (1986) based on cohort studies of North American Hutterites[7] from the 16th to early 20th centuries.[8] In reality, however, the source of data is the same as that for Fig. 2—a collection of ten demographic records from various populations in Europe, Africa, Asia, and North America. Eight of the ten populations are not North American Hutterites. This omission can be easily detected if you look at the figure on Menken et al. (1986, p. 1390), because it is accompanied by legends about the data sources with geographical names such as Norway, Tunis, and Iran. It is thus obvious that neither the author nor the reviewer nor the JSRM editorial committee looked at the original figure with their own eyes.

The figure also contains other mistakes. The curve captioned "17th century" corresponds to data from Hutterites in the 20th century on the original figure. The curve captioned "20th century" does not exist in the original: It is a composite of two curves of the data from the bourgeoisie in Genova in the 17th century and from Norway in the 19th century.

What is the most problematic about Fig. 4a is the overall impression it creates. Fig. 4b shows five

[6] JSRM's website previously included this graph (JSRM, 2013, p. 33), but it was changed to a different one during a revision dated December 12, 2016.

[7] Hutterite is a religious group of Anabaptists known for its high birthrate (Sheps, 1965).

[8] Takahashi T. (2014) provides the slightly different explanation that the data are from 16th to late-19th centuries.

curves that Fig. 4a does not include. Fig. 4b shows, with some variations, a common pattern of having a rounded curve. The curve's gradient is moderate during the 20s and early 30s, and then becomes greater in the late 30s. In contrast, Fig. 4a gives an overall impression of steeper curves. The curve captioned "20th century," for example, seems to be almost linearly declining. JSRM (2014) thus extracted curves with large gradients.

Manipulated curve with a peak at age 22 by Yoshimura (2013)

Fig. 5a is the graph published in a supplementary textbook for high school health education (MEXT, 2015) as previously mentioned. The graph was made through a complicated process. The data displayed within it are derived from two sources: (1) Jain (1969) on the interval between marriage and the first conception of Taiwanese women in the 1960s, and (2) Sheps (1965) on ASMFR of American Hutterite women in the 1950s and 1960s. As will be explained in the following paragraphs, the data were manipulated at every step by which they arrived at their place in the graph: by Bendel & Hua (1978), by Wood (1989), and by O'Connor, Holman, & Wood (1998). Finally, Yoshimura (2013) published a simplified version of the graph on a website, an image that was similar to the one in Fig. 5a.[9] See Tanaka (2016a, 2017) for details of the process of data manipulation.

[Take in Figure 5]

In Fig. 5a, the effect of data manipulation is not serious between the ages of 16 and 22. The curve almost traces the values calculated from Jain (1969).

At age 22, however, the curve in Fig. 5a hits a peak and then starts to decline. This decline deviates from the original data. Jain (1969) reported an increasing value until a peak at age 24. This manipulation, in which the peak was located at age 22, was by Wood (1989).

For ages 25 and over, the data are derived from Sheps (1965). That part of the curve has a serious problem, because it is based on an estimation by Bendel & Hua (1978) that trimmed away the data for women married later in life, who exhibited a high fertility even at more advanced ages. Fig. 5b is based on the original figures by Sheps (1965, Table 2) that indicated ASMFR based on age at marriage. Data are converted to 3-year moving averages in order to smooth cyclical fluctuation in ASMFR. Fig. 5b demonstrates that fertility is high immediately after marriage and then decreases. Thus, the data show that couples in their "newlywed" period exhibit high fertility, regardless of the wives' ages. Bendel & Hua (1978), however, trimmed away the data for women married in their late-20s and 30s (shown as the two dotted lines in Fig. 5b). They only used data for women married as teenagers or in their early 20s (the two solid lines in Fig. 5b) to estimate the pattern of *fecundability* (monthly probability of conception) behind the ASMFR, using a set of extrapolated parameters from other data. Their estimation consequently showed a steep decline, reflecting the reduced intercourse frequency of couples with a longer marital life (Tanaka, 2017).

Yoshimura (2013) made a graph similar to Fig. 5a based on a figure that had already been manipulated. In the graph, Yoshimura (2013) simplified the curve by plotting only seven points. He also shifted four points for the 20s and 30s to the left. These manipulations made a straight declining line after the age of 25 on Fig. 5a. Using this graph, Yoshimura illustrated that women's fertility declines from their 20s due to the decrease in the number of eggs, as well as to the deterioration in the quality of eggs (Tanaka 2017). Curiously, in Yoshimura's graph, the peak is located near age 21, although it is labeled as "22" (Nishiyama & Tsuge, in press). When the graph appeared on the high school supplement textbook (Fig. 5a), the peak was moved to the correct position and the vertical axis was labeled as "ninsin no siyasusa" (ease of conception).

[9] Yoshimura Yasunori is an emeritus professor of Keio University. He filled various posts in academic associations, such as the chairperson of the executive board of JSOG (2007–2011) and JSRM (2010–2014). He has also served as a special advisor to the Cabinet since March 2013 about measures to counter the declining birthrate and support for child-raising.

Authorization and Circulation of the Graphs

It is important to note that such data were not used only by individual professionals—organizations of professionals actively used and endorsed them as well. Before Fig. 5a was published by MEXT (2015), a different version of it was used in a document prepared by nine associations: JSRM, JAOG, Japan Society of Obstetrics and Gynecology (JSOG), Japan Society of Maternal Health, Japan Society of Perinatal and Neonatal Medicine, Japan Society of Gynecologic Oncology, Japan Society for Menopause and Women's Health, Japan Society of Adolescentology, and Japan Family Planning Association (JFPA, 2015). The document was submitted to Arimura Haruko (then the minister in charge of measures to counter the declining birthrate) on March 2, 2015, as substantiation for the claim that schools should teach fertility issues—in particular, medical knowledge regarding the age-related decline of women's fertility. Lobbying by these organizations was effective in encouraging the Japanese government's implementation of the new pronatalist policy (Nishiyama & Tsuge, in press).

Among the nine organizations, JSRM is the most active in broadcasting unscientific data. In September 2015, JSRM issued a statement of the chairperson of its executive board (Irahara, 2015) to justify the use of Fig. 5a in the high school supplementary textbook (MEXT, 2015). In the statement, Irahara (2015) referred to the work of Dunson et al. (2002), which carries Fig. 3a, as one piece of evidence supporting the validity of the graph. JSRM also published Fig. 4a in a textbook (JSRM, 2014) as well as on its official website as part of a collection of information for people seeking knowledge on fertility issues (JSRM, 2013). JSRM has distributed all of the three graphs.

For the policy-making process, obstetricians and gynecologists played a part in introducing unscientific data as advisory experts. Saito Hidekazu presented modified versions of Fig. 3a, Fig. 5a, and the figure from IFDMS (Bunting et al., 2013) to government committees (Saito, 2014a, 2014b, 2015) to advocate new policies to introduce fertility-related knowledge in education. Yoshimura Yasunori offered the government Fig. 5a for the editorial process of the high school supplementary textbook (Nishiyama & Tsuge, in press).

The unscientific graphs also appeared in books, magazines, online articles, and lectures targeted at general audiences. Fig. 3a appeared in a book about fertility and women's life plans written by an obstetrician/gynecologist and journalist (Saito & Shirakawa, 2012). Kawai (2013, 2015) also featured a similar graph from Dunson et al. (2002), based on interpretations by Saito Hidekazu (Kawai, 2015). Further, Tarui (2014) used Fig. 4a. For examples of graphs similar to Fig. 5a, see Takahashi S. (2015) and Tanaka (2017).

Based on such conduct by doctors and their organizations, we can estimate their motives and strategies. Since reproductive medicine developed as an industry, doctors have suffered from the low success rate of infertility treatments. Doctors came to believe that the delaying of childbirth is the main cause for such a low success rate, and Saito & Shirakawa (2012, p. 39) declare this belief to be the reason for their "propaganda" of egg aging. On the other hand, doctors' organizations realized the social demands for expert knowledge to cope with the low fertility today and thus assumed new political roles to offer their opinions on fertility issues to the public (Kuribayashi, 2014). In addition to these conditions, doctors tend to have a paternalistic view of education. Kinoshita (2015) states as the president of JAOG that it is the responsibility of the national organization of obstetricians and gynecologists to instill notions of healthy pregnancy and childbearing in children.

Effects of the Manipulated Data

The egg aging campaign gripped the attention of people and the government. Manipulated graphs were effective during the campaign and contributed to creating widespread perception biases in Japanese

society today. In addition to the self-image of Japan as a society lacking fertility knowledge produced by IFDMS, two points are important.

First, as the graphs exaggerate age-related decline in biological fertility, they create the impression that women aged 30 and over have only limited possibility of conceiving. From the viewpoint of the government, which aims to increase the number of childbirths, the data suggest that it is necessary to encourage pregnancy at an earlier stage in life. This view was openly expressed by Amano (2015). Saito (2014a, p. 17) argued that the average maternal age at one's first childbirth should be five years earlier than it is today.[10] Cabinet Office (2014, p. 5) picked up an opinion by an expert of reproductive medicine (maybe Saito Hidekazu) that it is desirable for the age-specific fertility rate curve to have its peak at the ages between 23 and 25. The current Japanese government thus continues to repeat the pronatalist policy of the 1940s (Schoppa, 2008) to encourage early marriage.

This interpretation is accompanied with underestimation of the potential fertility of women in their 30s and 40s, a finding that conflicts with an age-fertility curve showing a round shape like Fig. 2, which demonstrates no large decline before the mid-30s. Fig. 2 exhibits 0.3 or 0.4 ASMFR for the 30s in natural fertility populations. This suggests that today's ASMFR for women in their 30s, which was 0.16 or lower in 2010 (IPSS, 2016a, Table 4-12), is significantly lower than the biological limit. It accordingly implies that current social and cultural factors suppress fertility, and so there is a margin for raising fertility through employing policies for the improvement of Japan's social environment.

Second, the graphs imply that it is more suitable for young women to have children, as they assume a rapid decrease from the mid-20s onwards. As the government intends to disseminate this knowledge, youths in their teenage years or early 20s will become targets. For instance, the mayor of Urayasu City talked to youths on the verge of becoming 20 years old at a coming-of-age-ceremony about how a woman's suitable age for childbirth is between 18 and 26 (Mainich Shinbun, 2016). The aforementioned supplementary textbook (MEXT, 2015) targeted high school students, particularly those as young as 15 years old. Teenagers have therefore faced pressure to develop a rational life plan in which they become pregnant during the "suitable" period.

It is noteworthy that such life-planning education is targeted mainly at girls. MEXT (2015, p. 38) presents an example of a life plan for a girl, without such an example for a boy. Although there have been medical research findings about male infertility and the medical industry has started to target at men as potential patients for infertility treatment, such issues are mentioned only as supplements. Generally speaking, life-planning education carries a latent message that it is women's responsibility to manage their fertility and develop a life plan in which they bear a desirable number of children (Fassbender, 2016).

Gender and Biology: Prospects for Political War with Science as a Social Institution

In this paper, I explain the recent egg aging panic and faulty graphs used to justify pronatalist policies. This paper focuses on Japan, but similar problems may occur in any society in which (1) low fertility is recognized as a high-priority political agenda and (2) doctors have strong social influence. Regarding the second factor, I address four important points indicating that unscientific practices may prevail in the field of obstetrics, gynecology, and reproductive medicine worldwide.

1. There is evidence of misconduct such as data-falsification and data-trimming.
2. Professionals committed elementary-level errors, such as wrong description of data and incorrect values plotted on their graphs. These could easily be avoided if these professionals carefully read the works they cite.

[10] The National Governors' Association (2014) made the same policy proposal, but it is unclear that the proposal was based on the consideration of biological fertility decline with advanced age.

3. Papers featuring non-replicable statistical estimations (Dunson et al., 2002) and a low-quality survey (Bunting et al., 2013) were published in an academic journal. These articles were approved as if they were the results of reliable research.

4. There has been no critical discussion regarding the misconduct within the professional community.

These facts lead to suspicion about research integrity and research standards in the field of fertility studies. We can no longer assume the faithful behavior of professionals and research that attains the minimum standards of quality.

Present criticisms notwithstanding, it seems that there has been no negative impact on the perceived legitimacy of fertility research. Despite criticisms leveled against the professionals and associations, they—Yoshimura Yasunori, Saito Hidekazu, Takahashi Toshifumi, JSRM, JAOG, JSOG, and their cohort—have not been penalized and continue to behave in the same manner. This suggests that science is considered legitimate as long as it remains inside an established social institution with the power to confer that legitimacy. In short, the legitimacy of science is not a subject of science itself, but of politics. If we require science to be scientific, it is necessary to engage in political discourse over its legitimacy.

Finally, I would like to highlight the historical context where the biological explanation was introduced in the public discourse about fertility issues in Japan. We can identify this phenomenon as a part of a right-wing backlash over the past twenty years against social movements and policies promoting diversity and equality. The current pronatalist policy is under administration by a right-wing government who put a high priority on protecting the values of the traditional family system and gender norms. When this government expects people to lead a healthy life according to medically correct knowledge, it is in effect expecting that men and women follow the traditional, normative life course. The problem is not merely in the conduct of scientists, but in the way that science has been politically mobilized to justify traditional social orders.

In this respect, it is important for gender policy to confront obstructionism from the sciences. Gender policy is always in tension with science, because social gender issues are always related to biological sex differences. On one hand, gender policies should apply scientific research findings to effectively realize a more gender-egalitarian society. On the other hand, scientific concepts are often used to perpetuate gender myths and to justify gender discrimination in social order. We already have a list of such dangerous concepts: gene, hormone, brain, and so on. Now we should append a new member of the list, “egg aging,” to alert people to the unscientific discourses on fertility and to combat unscientific science.

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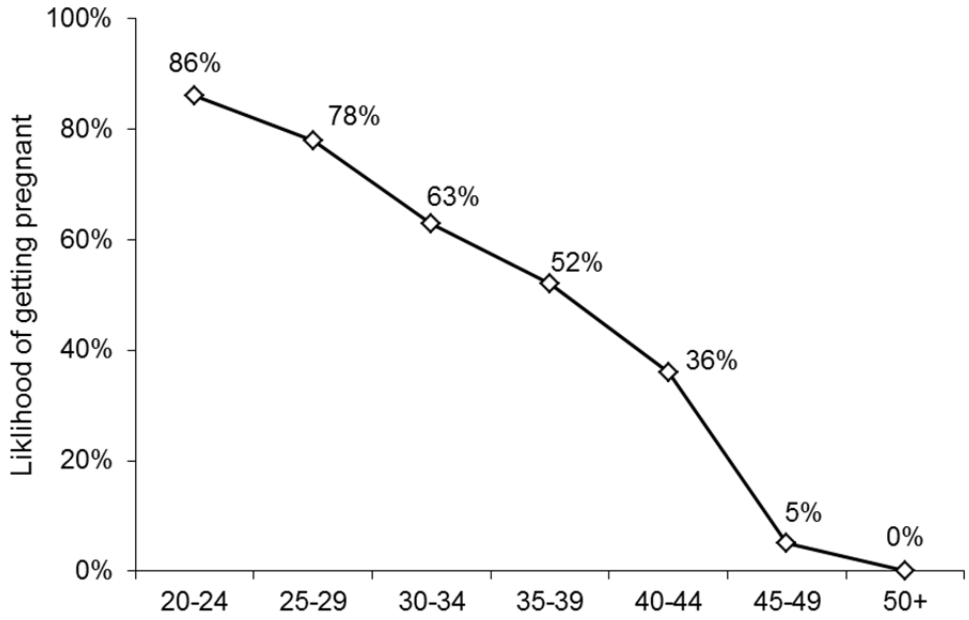
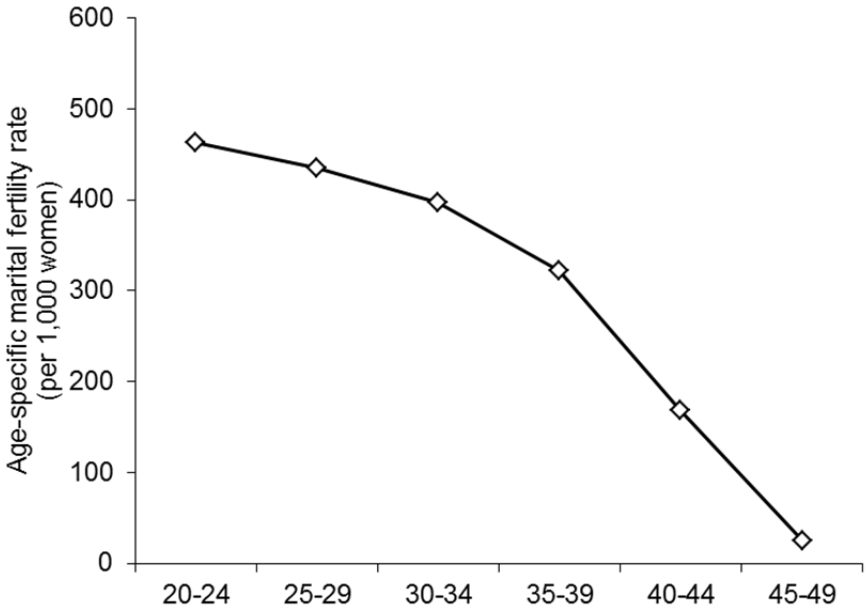
Figures



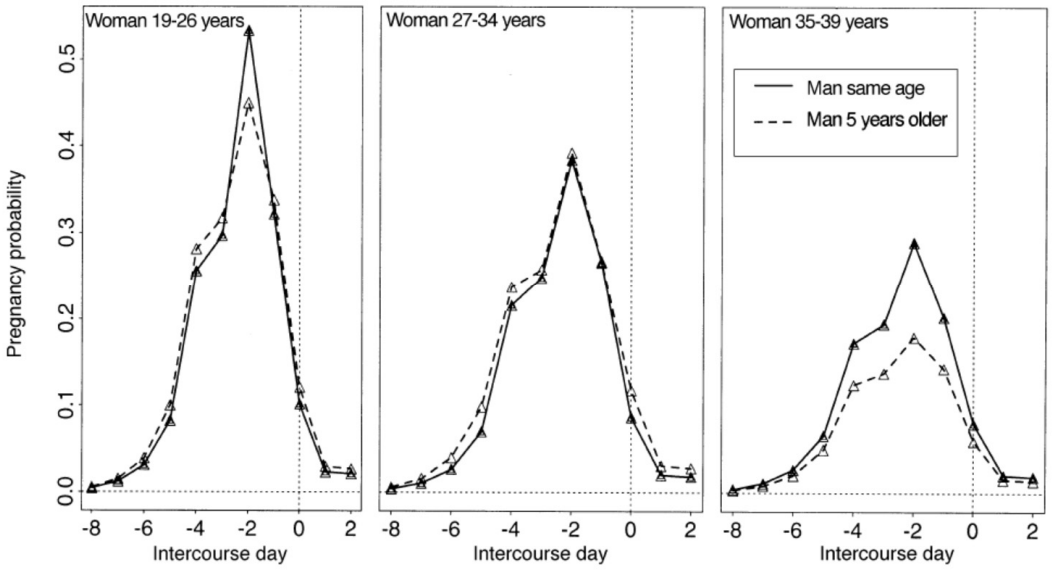
Created from Carcio (1998, Table 2-5) for the 20s and 30s; Rosenthal (1998, Table 1.1) for the 40s and over.

Fig. 1. A faulty graph of the likelihood of getting pregnant linearly declining with age



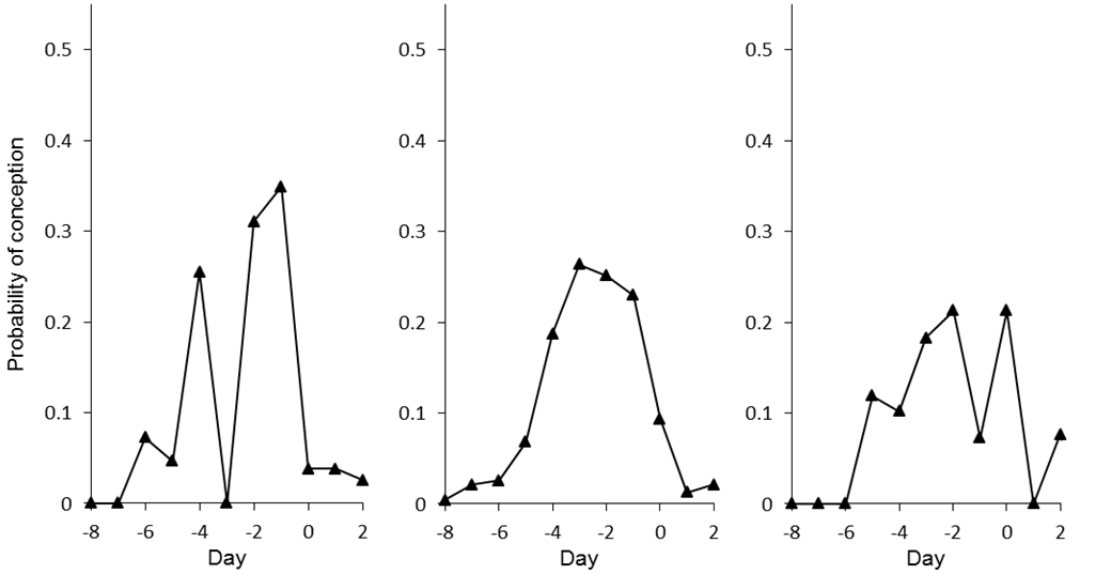
Created from the "Typical age pattern" by Menken & Larsen (1986, Table III). Data sources are listed in Henry (1961).

Fig. 2. Average age pattern of marital fertility rates from ten natural fertility populations



Replicated from Dunson, Columbo, & Baird (2002, p. 1402) by permission of Oxford University Press.

(a) Bayesian estimates by Dunson et al.

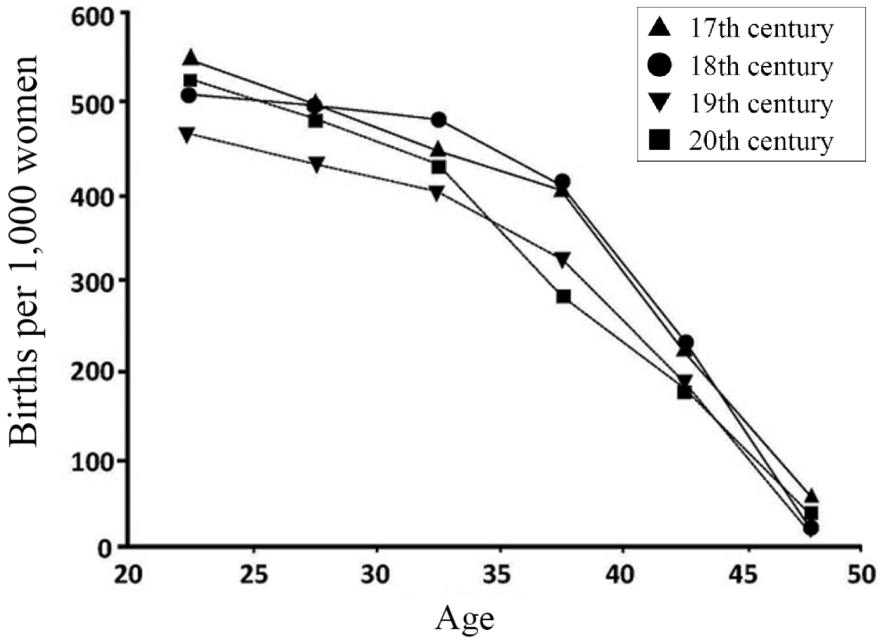


Women 18–24 years (*N*=103). Women 25–34 years (*N*=596). Women 35–39 years (*N*=83).

Created based on Colombo & Masarotto (2000, pp. 12, 36)

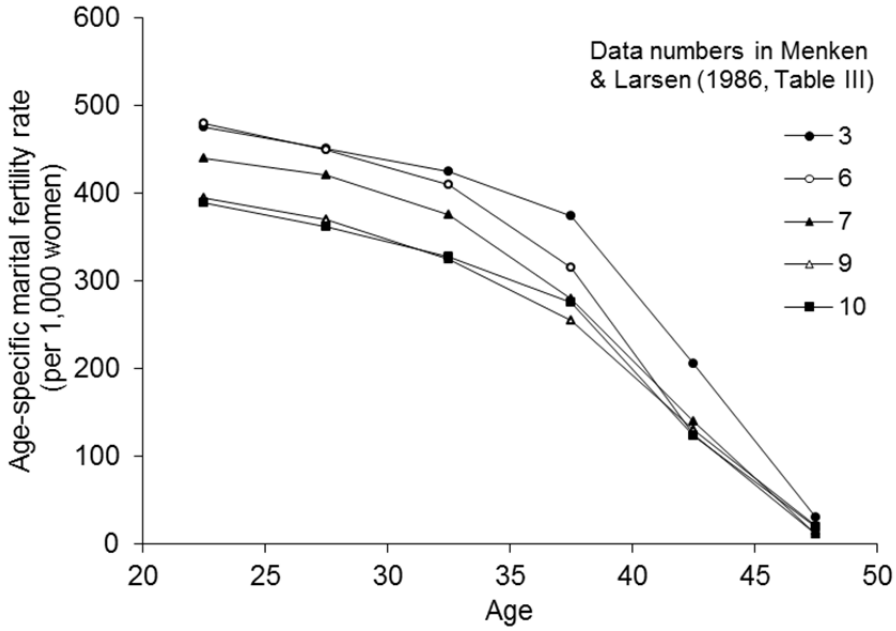
(b) Estimate by the formula of Schwartz et al. (1980)

Fig. 3. Daily fecundability estimates from a European multicenter study (1992–1996)



Adapted from Tarui (2014) with my translation.

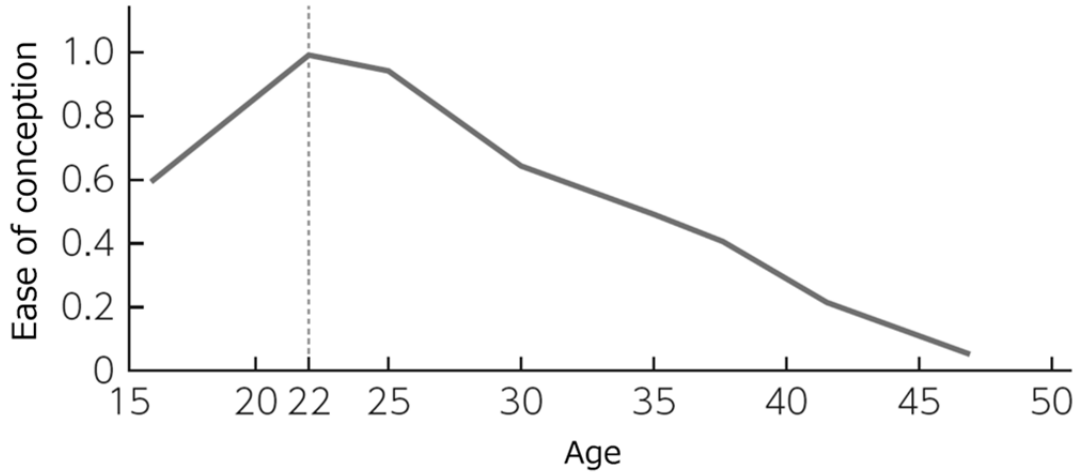
(a) Four curves extracted from Menken et al. (1986)



Created from Menken & Larsen (1986, Table III). Data sources are listed in Henry (1961).

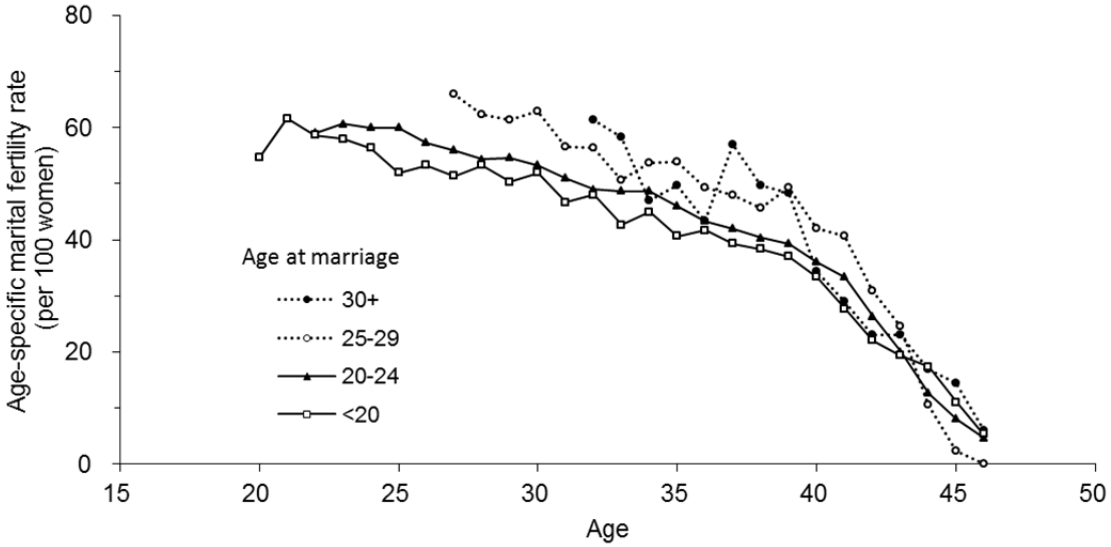
(b) Other five curves

Fig. 4. Age-specific marital fertility rates in some natural fertility populations



Adapted from MEXT (2015) with my translation. Original in color.

(a) On the high school supplementary textbook



Three-year moving average calculated from Sheps (1965, Table 2). See Tanaka (2017).

(b) Age-specific marital fertility rates in an American Hutterites community (1950s and 1960s).

Fig. 5. The manipulated graph with the peak at age 22