HHS Public Access

Author manuscript

BJOG. Author manuscript; available in PMC 2019 November 01.

Published in final edited form as:

BJOG. 2018 November ; 125(12): 1541–1548. doi:10.1111/1471-0528.15218.

Lubricant use during intercourse and time-to-pregnancy: A prospective cohort study

Kathryn A. McInerney[a], **Kristen A. Hahn**[a], **Elizabeth E. Hatch**[a], **Ellen M. Mikkelsen**[b], **Anne Z. Steiner**[c], **Kenneth J. Rothman**[a,d], **Henrik T. Sørensen**[a,b], **Thala M. Snerum**[e], and **Lauren A. Wise**[a]

[a]Department of Epidemiology, Boston University School of Public Health, 715 Albany Street, Boston, MA, 02118 USA

[b]Department of Clinical Epidemiology, Aarhus University Hospital, Olof Palmes alle 43-45, 8200 Aarhus N, Denmark

[c]Department of Obstetrics and Gynecology, University of North Carolina, 4001 Old Clinic Building #7570, Chapel Hill NC 27599 USA

[d]RTI Health Solutions, P.O. Box 12194, Research Triangle Park, NC, 27709 USA

[e]Pediatric Department, Regional Hospital Viborg, Heibergs Alle 4, 8800 Viborg, Denmark

Abstract

Objective—To assess the extent to which lubricant use during intercourse is associated with time-to-pregnancy (TTP).

Design—Prospective cohort study.

Setting—Denmark and North America.

Population—6,467 women aged 18-49 years who were not using contraception or fertility treatment.

Methods—We pooled data from two ongoing prospective cohort studies of pregnancy planners in Denmark (2011-2017) and North America (2013-2017). Female participants completed bimonthly questionnaires for 12 months or until reported pregnancy. After restricting to women without a

Corresponding Author: Kathryn A. McInerney, Department of Epidemiology, Boston University School of Public Health, 715 Albany Street, 3rd floor, Boston, MA 02118, 716-713-8752, mcinerney.ka@gmail.com.

Disclosures

The authors have no conflicts of interest to disclose. Completed disclosure of interest forms are available to view online as supporting information.

Author Contributions: K.A.M. performed data management, analyses and drafted the manuscript. K.A.H. performed data management, analyses and assisted with compilation of the manuscript. L.A.W. planned and implemented the PRESTO & SF studies, assisted with data analysis, and oversaw analytic decision-making and compilation of the manuscript. K.J.R., E.M.M., E.E.H., and H.T.S. planned and implemented the PRESTO & SF studies and assisted with analytic decision-making and compilation of the manuscript. A.Z.S. and T.M.S. assisted with exposure classification, provided clinical guidance on the interpretation of study results, and assisted with compilation of the manuscript.

Details of Ethical Approval

The Danish Data Protection Board (November 28, 2017; Reference: H-28795) and the Boston Medical Center Institutional Review Board (March 17, 2017, Reference: H-31848) approved the data collection tools and overall study protocols, and participants provided online informed consent.

history of infertility who had been trying to conceive for ≤6 cycles at enrollment, 6,467 women were retained for analysis. Self-reported lubricant use was categorized as water-based/not pH balanced, water-based/pH balanced ("fertility friendly"), silicone-based, oil-based, or a combination of these. We used proportional probabilities models to calculate fecundability ratios (FRs) and 95% confidence intervals (CIs) for the association between lubricant use and fecundability after adjusting for cohort and socio-demographic and lifestyle factors.

Main Outcome Measures—Fecundability.

Results—At baseline, 17.5% of participants reported use of lubricants, most commonly water-based/not pH balanced (11.4%). Compared with non-use of lubricants, FRs were 1.02 (95% CI: 0.93-1.11) for water-based/not pH balanced lubricant use, 1.01 (95% CI: 0.86-1.18) for water-based/pH balanced ("fertility friendly") lubricant use, 1.23 (95% CI: 0.94-1.61) for oil-based lubricant use, and 1.27 (95% CI: 0.93-1.73) for silicone-based lubricant use. Associations between oil-based lubricant use and fecundability were inconsistent across subgroups of study cohort, age, parity, and intercourse frequency.

Conclusions—Lubricant use was not associated with reduced fecundability in the preconception cohorts of pregnancy planners studied

Keywords

lubricant; fertility; cohort; epidemiology; fecundability

Introduction

Female sexual arousal is a complex process beginning with neural signaling and ending with vaginal lubrication.[1] Low estrogen levels can disrupt this process and result in vaginal dryness and pain during intercourse.[1] Vaginal lubricants are used during intercourse to increase satisfaction.[2, 3] In a nationally-representative sample of U.S. women, 65.5% reported using a commercially-available lubricant during the past year and 20.0% reported using a commercially-available lubricant during the past month.[3] Occasional vaginal dryness is reported by most couples trying to conceive,[4] perhaps because of higher intercourse frequency,[5] increased stress, and the lack of spontaneity often associated with timed intercourse. One study found that 28.6% of couples attempting to conceive reported occasional use of lubricants during intercourse and 14.3% reported frequent use.[5]

The association between lubricant use and fecundability has not been studied extensively. *In vitro* studies have found that exposure to common water-based,[6–10] oil-based,[11] or silicone-based[12] lubricants was associated with reduced sperm motility and viability, with adverse effects varying by type of water-[11, 12] or oil-based[8–10, 13] lubricant and with increasing lubricant concentration[13, 14] or exposure time.[8–10] In these laboratory studies, adverse effects of oil-[8, 9, 13] and silicone[9]-based lubricants were generally absent when semen samples were exposed for <5 minutes to oil-based lubricants and for <30 minutes to silicone-based lubricants. The water-based lubricant Pre-Seed® is marketed as a fertility-friendly lubricant because it has the same pH as cervical fluid. Pre-Seed® is associated with minimal or no adverse effects on semen parameters studied *in vitro*.[12, 15–17]

The association between lubricant use and fecundability has been examined in only one epidemiologic study, a prospective time-to-pregnancy (TTP) cohort study of 296 women aged ≥30 years. Contrary to findings from *in vitro* semen analyses, lubricant use was not associated with fecundability, even when used during the fertile window.[5] Small study size precluded the analysis of different types of lubricants.[5] In the present prospective cohort study of Danish and North American couples, we examine the association between use of lubricants, and its specific types, and fecundability.

Methods

Study population

To enhance precision, data from two ongoing prospective preconception cohort studies were pooled in this analysis. In Denmark, the Snart Foraeldre (SF) study (August 2011-present) recruits women aged 18-49. In the United States and Canada, Pregnancy Study Online (PRESTO) (June 2013-present) recruits women aged 21-45.[18] In both cohorts, eligible participants are in a relationship with a male partner, trying to conceive, and not currently pregnant, using contraception or fertility treatments.

SF and PRESTO have nearly identical study designs. Data are collected via online questionnaires. At baseline, women report information about demographics, behaviors, lifestyle factors, and medical history. They complete follow-up questionnaires every 2 months until reported pregnancy, initiation of fertility treatment, loss to follow-up, or 12 months, whichever occurs first. Over 80% of enrolled participants have completed at least one follow-up questionnaire.

The Danish Data Protection Board (November 28, 2017; Reference: H-28795) and the Boston Medical Center Institutional Review Board (March 17, 2017, Reference: H-31848) approved the data collection tools and overall study protocols, and participants provided online informed consent. Funding for this study was provided by the National Institutes of Health (R01-HD060680, R01-HD086742, R21-HD050264, R21-HD072326, and T32-HD052458). The funding agency did not play a role in the conduct of research or manuscript preparation.

Assessment of lubricant use

At baseline, women in both cohorts reported whether they typically used a lubricant during intercourse (yes vs no). In PRESTO, past-month users reported the name(s) of the lubricant(s) they used (check all that apply) and frequency of use (“occasionally”, “frequently”, “all the time”). A list of common lubricants was provided, including KY Jelly®, Astroglide®, Silk®, Wet®, Replens®, Pre-Seed®, Vaseline®, FemGlide®, baby oil, and olive, vegetable, or other plant- or animal-based oil. An open-ended text field was also provided for “other type,” and women could report “don’t know” as an option. In SF, women were asked to indicate the name of the lubricant(s) they used most frequently in an open-ended text field. In PRESTO, information about past-month lubricant use was elicited on each follow-up questionnaire.

Assessment of covariates

On the baseline questionnaire, female participants reported detailed data on demographics (age, race/ethnicity); socioeconomic position (education, income, marital status); lifestyle factor, anthropometrics; reproductive, and medical history; and characteristics of their male partners (i.e., age, smoking, height, weight, and education). Females reported on the frequency of intercourse and methods used to improve one's chances of conception (e.g., charting menses, ovulation testing, cervical fluid monitoring, recording of basal body temperature) on the baseline and follow-up questionnaires. Body mass index was calculated as weight (kg)/height $(m)^2$.

Assessment of pregnancy and cycles at risk

At baseline, female participants reported their date of last menstrual period (LMP), typical menstrual cycle length, and number of menstrual cycles of pregnancy attempt time since discontinuing contraception. On follow-up questionnaires, female participants reported their LMP date and pregnancy status. Cycles at risk were calculated as (reported menstrual cycles of attempt time at study entry) + [(LMP date from most recent follow-up questionnaire - date of baseline questionnaire)/menstrual cycle length] + 1. Women contributed cycles to the analysis until conception, commencement of fertility treatments, loss-to-follow-up, or 12 cycles, whichever occurred first.

Exclusions

We excluded participants if they reported implausible menstrual cycle information (*i.e.*, LMP date >6 months before the baseline questionnaire, no pregnancy and no new LMP over follow-up, or reported baseline LMP date was after the baseline questionnaire completion date), if they had been trying to conceive for >6 cycles at study entry, or if they had previously tried to conceive for ≥12 months without becoming pregnant (*i.e.* history of infertility). Figure 1 displays the number of women excluded from each study cohort. The final analytic population included 2,588 women from SF and 3,879 women from PRESTO, for a total of 6,467 women.

Data analysis

Lubricants were categorized by their base and pH balance. The base was taken as the first ingredient listed on the product label (water, oil, or silicone). Water-based lubricants were then divided into two categories: those engineered to match the pH of cervical fluid (7.0),[19] referred to as water-based/pH balanced ("fertility friendly"); and those that are water-based but not pH balanced to the cervical fluid. Women who used more than one type of lubricant were analyzed separately. Mutually-exclusive categories included water-based/not pH balanced; water-based/pH balanced ("fertility friendly"); silicone-based; oil-based; and mix of types.

Life table methods were used to compute the cumulative proportion of pregnancy during 12 cycles of follow-up. We used proportional probabilities regression models to estimate fecundability ratios (FRs) and 95% confidence intervals (CIs).[20] The FR is the average per-cycle probability of conception comparing lubricant users to non-users; FRs <1 indicate longer TTP among exposed than unexposed. The proportional probabilities model adjusts

for observed cycle number, accounting for declining average fecundability among couples over analysis time.[20] We used the Andersen-Gill data structure to account for differences in attempt time at enrollment (0-6 cycles) and to reduce bias from left truncation.[21–23] For example, if a woman entered the study with 1 cycle of attempt and conceived during the 3rd cycle, she contributed cycles 2 and 3 to the analysis. We used the weighted copy method to minimize convergence issues produced by the regression model.[24]

We identified potential confounders *a priori* using a directed acyclic graph. These *a priori* variables included study cohort (SF versus PRESTO), age (<25, 25-29, 30-34, 35-39, ≥40 years), education (≤12, 13-15, 16, ≥17 years), household income (< versus ≥ 50,000 U.S. dollars/300,000 Danish kroners per year), non-Hispanic white (yes/no), BMI (<18.5, 18.5-24, 25-29, ≥30 kg/m^2), cigarette smoking (current, past, never), and doing something to improve chances of conception (e.g. timing intercourse around the fertile window, monitoring consistency of cervical mucus, testing for ovulation) (yes versus no). Results were examined with and without adjustment for intercourse frequency (<1, 1, 2-3, ≥4 times per week), which is a potential causal intermediate.[25, 26]

Secondary analyses, conducted only in PRESTO due to data availability, examined frequency of use (“occasionally”, “frequently”, “all the time”), and updated lubricant use over time based on reports from bimonthly follow-up questionnaires.

We examined effect measure modification by age (<30 versus ≥30 years),[27] BMI (<30 versus ≥30 kg/m^2),[28] and parity (0 versus ≥1 birth)[29] because natural vaginal lubrication may vary across these subgroups. We stratified our analyses by cohort (PRESTO versus SF) to account for differences in exposure assessment. We also stratified by pregnancy attempt time at study entry (0-2 versus 3-6 cycles) and intercourse frequency (<2 versus ≥2 times per week).

Missing data for covariates and exposure ranged from 0.5% (education) to 2.7% (lubricant type); there were no missing data for age. Pregnancy status was missing for 12.2% of couples. We imputed missing values for exposure, covariates, and outcome using PROC MI to create five imputed datasets. We used PROC MIANALYZE to combine coefficient and standard error estimates.[30]

Results

Over the study period, 76.3% of couples achieved pregnancy (PRESTO 72.0%, SF 82.7%). Lubricants were used by 17.5% of participants; 11.6% of SF participants and 21.4% of PRESTO participants reported lubricant use (Table 1). Participants most often used water-based/not pH balanced (11.4%), followed by water-based/pH balanced (“fertility friendly”) (3.9%), oil-based (1.1%), and silicone-based (0.6%) lubricants. Only 0.6% of participants used more than one type of lubricant. At study entry, users and non-users of lubricants had similar mean pregnancy attempt times (1.9 cycles vs. 2.0 cycles) and the prevalence of lubricant use was similar for women with shorter vs. longer attempt times (1 cycle: 17.8% vs. 6 cycles: 18.2%).

Lubricant use was positively associated with household income and educational attainment. Lubricant users had less frequent intercourse than non-users. SF participants were more likely than PRESTO participants to use silicone-based lubricants and less likely to use water-based/pH balanced lubricants. Compared with all other participants, users of silicone-based lubricants were more likely to have a college education, higher household income, and lower BMI. Users of water-based/pH balanced lubricants had the longest attempt time at study entry (2.7 cycles) and were less likely to have a college degree than users of other types of lubricants or non-users. Women who used more than one type of lubricant were older and less likely to be non-Hispanic white compared with women who used a single type (Table 1).

FRs for lubricant use compared with non-use were 1.02 (95% CI: 0.93-1.11) for water-based/not pH balanced lubricants, 1.02 (95% CI: 0.93-1.12) for water-based/pH balanced lubricants, 1.27 (95% CI: 0.93-1.73) for silicone-based lubricants, 1.23 (95% CI: 0.94-1.61) for oil-based lubricants, and 1.18 (95% CI: 0.79-1.77) for use of more than one type of lubricant (Table 2). Results were similar with and without adjustment for intercourse frequency.

Oil-based lubricant use was associated with increased fecundability among PRESTO but not appreciably associated among SF participants (Table 3). Among participants in both cohorts, oil-based lubricant use was associated with increased fecundability among users who were older, nulliparous, or had less frequent intercourse compared with non-users. There was little association between use of oil-based lubricant and fecundability among participants who were younger, parous, or had more frequent intercourse. Parous women who used water-based/pH balanced “fertility friendly” lubricants had slightly reduced fecundability compared with non-users (Table 3). Results were consistent across strata of attempt time at study entry and BMI (data not shown).

Frequency of lubricant use was ascertained in PRESTO only. While there was little overall association between frequency of lubricant use and fecundability, we observed a dose-response association between frequency of oil-based lubricant use and fecundability: women using oil-based lubricants “all the time” had an FR of 1.89 (95% CI: 1.26-2.82). Likewise, women using water-based/pH balanced lubricants “all the time” had an FR of 1.26 (95% CI: 0.99-1.60). The small number of PRESTO silicone-based lubricant users precluded interpretation of results by timing and frequency (data not shown).

In time-varying analyses among PRESTO participants, lubricant use remained relatively consistent over follow-up; 89.5% of PRESTO participants who reported lubricant use at baseline also reported lubricant use on their last follow-up questionnaire, while 10.5% of baseline users discontinued use. Results from time-varying analyses were consistent with the time-invariant results (data not shown).

Discussion

Main Findings

In this population of 6,467 female pregnancy planners without a history of infertility, there was no indication of strong adverse effects of lubricant use. We found small increases in fecundability among women who used oil- or silicone-based lubricants after adjusting for demographics and lifestyle factors. However, results for silicone-based lubricants were imprecise and results for oil-based lubricants were inconsistent across subgroups.

Strengths and limitations

This study has several limitations. Precision was limited by the small number of silicone and oil-based lubricant users, and the collection of frequency and time-varying use only in PRESTO. Further, lubricant use was recalled and is subject to error. Steiner and colleagues found moderate concordance between baseline self-report and daily diary tracking (kappa=0.46) of lubricant use; a minority of the participants who reported never using lubricants at baseline recorded occasional and frequent use in their diaries (26%).[5] The phrasing of questions in the present analysis varied across cohorts. PRESTO participants were asked about any lubricant use during the past month (using a checklist) and frequency of use, while SF participants were asked about lubricants they used frequently using an open-ended question. Additionally, we did not ask specifically about lubricant use during the fertile window. Any exposure misclassification in this prospective study is likely non-differential, biasing estimates towards the null. Pregnancy attempt time may have also been misclassified in the present study. If reporting accuracy varies by lubricant use, our results may be biased in either direction.[31] While our results did not change substantially after adjusting for measured potential confounders, residual confounding by unmeasured or unknown confounders is possible. Lastly, approximately 18% of participants were lost-to-follow-up before study completion; because follow-up was similar among users and non-users of lubricants, selection bias is unlikely.

This is the largest study of lubricant use and fecundability to date and the first to evaluate whether type of lubricant affects fecundability. Lubricant data were ascertained prospectively relative to fertility, reducing potential for differential misclassification of exposure and selection bias. Finally, we collected detailed covariate information, allowing control for multiple potential confounders, including age and education.

Interpretation

Our results agree with the sole previous study that examined the relation between lubricant use and fecundability.[5] Our results, and those from the study by Steiner et al.,[5] conflict with laboratory data showing adverse effects of lubricants on semen parameters.[6–14] Immediately following ejaculation, semen coagulates to reduce loss from the vagina and to protect sperm from the acidic vaginal pH;[32] although semen re-liquefies after about 20 minutes,[32] the first ejaculated sperm pass through the cervix in as little as one minute after ejaculation.[33–35] *In vitro* studies examine semen parameters after liquefaction and expose sperm to lubricants for longer than would occur during natural reproduction. Laboratory studies primarily examined

post-liquefaction semen parameters after 5 minutes[7, 8, 10, 12, 13, 15] to 24 hours of exposure,[17] with results that varied according to the duration.[8–10]

Use of oil-based lubricants was associated with slightly increased fecundability among PRESTO participants, with stronger results among couples who reported always using oil-based lubricants. Oil-based lubricant use was not appreciably associated with fecundability among SF participants. It is possible that women in SF and PRESTO use different types of oil-based lubricants; in studies of semen parameters after oil-based lubricant exposure, results varied by type of oil,[8–10, 13] with one study finding sperm hyperactivation after exposure to mustard oil.[10] If couples in Denmark and North America use different types of oils, this could account for the inconsistent results across cohorts. Our results may also be influenced by residual and unmeasured confounding. PRESTO couples using oil-based lubricants may be more health-conscious than non-users and, as a result, less likely to have poor diets or be exposed to environmental toxicants, which are more common in North America.[36–38]

While the small number of users of silicone-based lubricants hampered precision, our results indicate a modest but consistent increase in fecundability among users of such lubricants. Research examining semen parameters after exposure to silicone-based lubricants is sparse;[9, 12] one study examined varied lengths of exposure and found reduced motility after 60 minutes, but no meaningful difference after 1, 15, and 30 minutes of exposure.

Overall, we found that water-based/pH balanced (“fertility friendly”) lubricants were not associated appreciably with fecundability. Compared with non-users, fecundability was slightly reduced among users of water-based/pH balanced lubricants who were parous. Although we excluded women with a history of infertility to reduce potential for reverse causation, parous women with suspected subfertility may have chosen to use water-based/pH balanced (“fertility friendly”) lubricants.

Conclusions

Among Danish and North American pregnancy planners, lubricant use was not associated with reduced fecundability. Moreover, contrary to expectation, water-based/pH balanced (“fertility friendly”) lubricants were not associated with increased fecundability. If confirmed in subsequent studies, these results suggest that couples should use the lubricant that best suits their needs while trying to conceive.

Acknowledgments

We are grateful Michael Bairos for development and maintenance of the PRESTO technological infrastructures.

Funding: National Institute of Child Health and Human Development (R01-HD060680, R01-HD086742, R21-HD050264, R21-HD072326, and T32-HD052458)

Funding

This study was supported through funds provided by the Eunice Kennedy Shriver National Institute of Child Health and Human Development, National Institutes of Health (R01-HD086742, R03-HD090315, R21-HD072326, T32-HD052458).

References

1. Lara LA, Useche B, Ferriani RA, Reis RM, de Sa MF, de Freitas MM, et al. The effects of hypoestrogenism on the vaginal wall: interference with the normal sexual response. J Sex Med. 2009 Jan; 6(1):30–9. [PubMed: 19170834]
2. Braunstein S, van de Wijgert J. Preferences and practices related to vaginal lubrication: implications for microbicide acceptability and clinical testing. J Women's Health. 2005 Jun; 14(5):424–33.
3. Herbenick D, Reece M, Schick V, Sanders SA, Fortenberry JD. Women's use and perceptions of commercial lubricants: prevalence and characteristics in a nationally representative sample of American adults. J Sex Med. 2014 Mar; 11(3):642–52. [PubMed: 24521034]
4. Ellington J, Short R. Prevalence of vaginal dryness in trying-to-conceive couples. Fertil Steril. 2003; 79(Suppl 2):21–2.
5. Steiner AZ, Long DL, Tanner C, Herring AH. Effect of vaginal lubricants on natural fertility. Obstet Gynecol. 2012 Jul; 120(1):44–51. [PubMed: 22914390]
6. Froman DP, Amann RP. Inhibition of motility of bovine, canine and equine spermatozoa by artificial vagina lubricants. Theriogenology. 1983 Sep; 20(3):357–61. [PubMed: 16725851]
7. Tagatz GE, Okagaki T, Sciarra JJ. The effect of vaginal lubricants on sperm motility and viability in vitro. Am J Obstet Gynecol. 1972 May 01; 113(1):88–90. [PubMed: 5063461]
8. Goldenberg RL, White R. The effect of vaginal lubricants on sperm motility in vitro. Fertil Steril. 1975 Sep; 26(9):872–3. [PubMed: 1237417]
9. Kutteh WH, Chao CH, Ritter JO, Byrd W. Vaginal lubricants for the infertile couple: effect on sperm activity. Int J Fertil Menopausal Stud. 1996 Jul-Aug;41(4):400–4. [PubMed: 8894797]
10. Sandhu RS, Wong TH, Kling CA, Chohan KR. In vitro effects of coital lubricants and synthetic and natural oils on sperm motility. Fertil Steril. 2014 Apr; 101(4):941–4. [PubMed: 24462060]
11. Mowat A, Newton C, Boothroyd C, Demmers K, Fleming S. The effects of vaginal lubricants on sperm function: an in vitro analysis. J Assist Reprod Genet. 2014 Mar; 31(3):333–9. [PubMed: 24390681]
12. Agarwal A, Deepinder F, Cocuzza M, Short RA, Evenson DP. Effect of vaginal lubricants on sperm motility and chromatin integrity: a prospective comparative study. Fertil Steril. 2008 Feb; 89(2): 375–9. [PubMed: 17509584]
13. Anderson L, Lewis SE, McClure N. The effects of coital lubricants on sperm motility in vitro. Hum Reprod. 1998 Dec; 13(12):3351–6. [PubMed: 9886513]
14. Frishman GN, Luciano AA, Maier DB. Evaluation of Astroglide, a new vaginal lubricant: effects of length of exposure and concentration on sperm motility. Fertil Steril. 1992 Sep; 58(3):630–2. [PubMed: 1521661]
15. Abadie JM, Lambert HB. Effects of lubricants and wash solutions on semen evaluation in a fertility clinic laboratory. Lab Med. 2014 Spring;45(2):116–9. [PubMed: 24868991]
16. Agarwal A, Malvezzi H, Sharma R. Effect of an isotonic lubricant on sperm collection and sperm quality. Fertil Steril. 2013 May; 99(6):1581–6. [PubMed: 23490168]
17. Vargas J, Crausaz M, Senn A, Germond M. Sperm toxicity of "nonspermicidal" lubricant and ultrasound gels used in reproductive medicine. Fertil Steril. 2011 Feb; 95(2):835–6. [PubMed: 20971464]
18. Wise LA, Rothman KJ, Mikkelsen EM, Stanford JB, Wesselink AK, McKinnon C, et al. Design and Conduct of an Internet-Based Preconception Cohort Study in North America: Pregnancy Study Online. Paediatr Perinat Epidemiol. 2015 Jul; 29(4):360–71. [PubMed: 26111445]
19. Eggert-Kruse W, Kohler A, Rohr G, Runnebaum B. The pH as an important determinant of sperm-mucus interaction. Fertil Steril. 1993 Mar; 59(3):617–28. [PubMed: 8458467]
20. Weinberg CR, Wilcox AJ, Baird DD. Reduced fecundability in women with prenatal exposure to cigarette smoking. Am J Epidemiol. 1989 May; 129(5):1072–8. [PubMed: 2705427]
21. Howards PP, Hertz-Picciotto I, Poole C. Conditions for bias from differential left truncation. Am J Epidemiol. 2007 Feb 15; 165(4):444–52. [PubMed: 17150983]
22. Schisterman EF, Cole SR, Ye A, Platt RW. Accuracy loss due to selection bias in cohort studies with left truncation. Paediatr Perinat Epidemiol. 2013 Sep; 27(5):491–502. [PubMed: 23930785]

23. Therneau TM, Grambsch PM. Modeling Survival Data: Extending the Cox Model. New York, NY (USA): Springer-Verlag; 2000.
24. Deddens JA, Petersen MR. Approaches for estimating prevalence ratios. Occup Environ Med. 2008; 65(7):501–6.
25. Howards PP, Schisterman EF, Poole C, Kaufman JS, Weinberg CR. "Toward a clearer definition of confounding" revisited with directed acyclic graphs. Am J Epidemiol. 2012 Sep 15; 176(6):506–11. [PubMed: 22904203]
26. Weinberg CR. Toward a clearer definition of confounding. Am J Epidemiol. 1993 Jan 1; 137(1):1–8. [PubMed: 8434568]
27. Gracia CR, Freeman EW. Acute consequences of the menopausal transition: the rise of common menopausal symptoms. Endocrinol Metab Clin North Am. 2004 Dec; 33(4):675–89. [PubMed: 15501640]
28. Esposito K, Ciotola M, Giugliano F, Bisogni C, Schisano B, Autorino R, et al. Association of body weight with sexual function in women. Int J Impot Res. 2007 Jul-Aug;19(4):353–7. [PubMed: 17287832]
29. Barrett G, Pendry E, Peacock J, Victor C, Thakar R, Manyonda I. Women's sexual health after childbirth. BJOG. 2000 Feb; 107(2):186–95. [PubMed: 10688502]
30. Institute SAS. SAS/Stat 9.3 user's guide. Cary, NC; 2011.
31. Radin RG, Rothman KJ, Hatch EE, Mikkelsen EM, Sorensen HT, Riis AH, et al. Maternal Recall Error in Retrospectively Reported Time-to-Pregnancy: an Assessment and Bias Analysis. Paediatr Perinat Epidemiol. 2015 Nov; 29(6):576–88. [PubMed: 26443987]
32. Lopez KH, Jones R. Human Reproductive Biology. 4th. London, UK: Academic Press; 2014.
33. Settlage DS, Motoshima M, Tredway DR. Sperm transport from the external cervical os to the fallopian tubes in women: a time and quantitation study. Fertil Steril. 1973 Sep; 24(9):655–61. [PubMed: 4737661]
34. Kunz G, Beil D, Deininger H, Wildt L, Leyendecker G. The dynamics of rapid sperm transport through the female genital tract: evidence from vaginal sonography of uterine peristalsis and hysterosalpingoscintigraphy. Hum Reprod. 1996 Mar; 11(3):627–32. [PubMed: 8671281]
35. Suarez SS, Pacey AA. Sperm transport in the female reproductive tract. Hum Reprod Update. 2006 Jan-Feb;12(1):23–37. [PubMed: 16272225]
36. Wesselink AK, Wise LA, Janulewicz PA, Mikkelsen EM, McClean M, Tomsho K. , et al. Urinary concentrations of phenols and fecundability in two preconception cohort studies. Society for Epidemiologic Research 50th Annual Meeting; 2017 June 20-23; Seattle, WA. 2017.
37. Wise LA, Wesselink AK, Mikkelsen EM, Thayer KA, McClean M, Tomsho K. , et al. Perfluoroalkyl and polyfluoroalkyl substances and female fecundability in two preconception cohort studies. Society for Epidemiologic Research 50th Annual Meeting; 2017 June 20-23; Seattle, WA. 2017.
38. Hatch EE, Wesselink AK, Rosofsky A, Janulewicz PA, Mikkelsen EM, Rothman KJ. , et al. Urinary concentrations of phthalates and fecundability in two preconception cohort studies. Society for Epidemiologic Research 50th Annual Meeting; 2017 June 20-23; Seattle, WA. 2017.

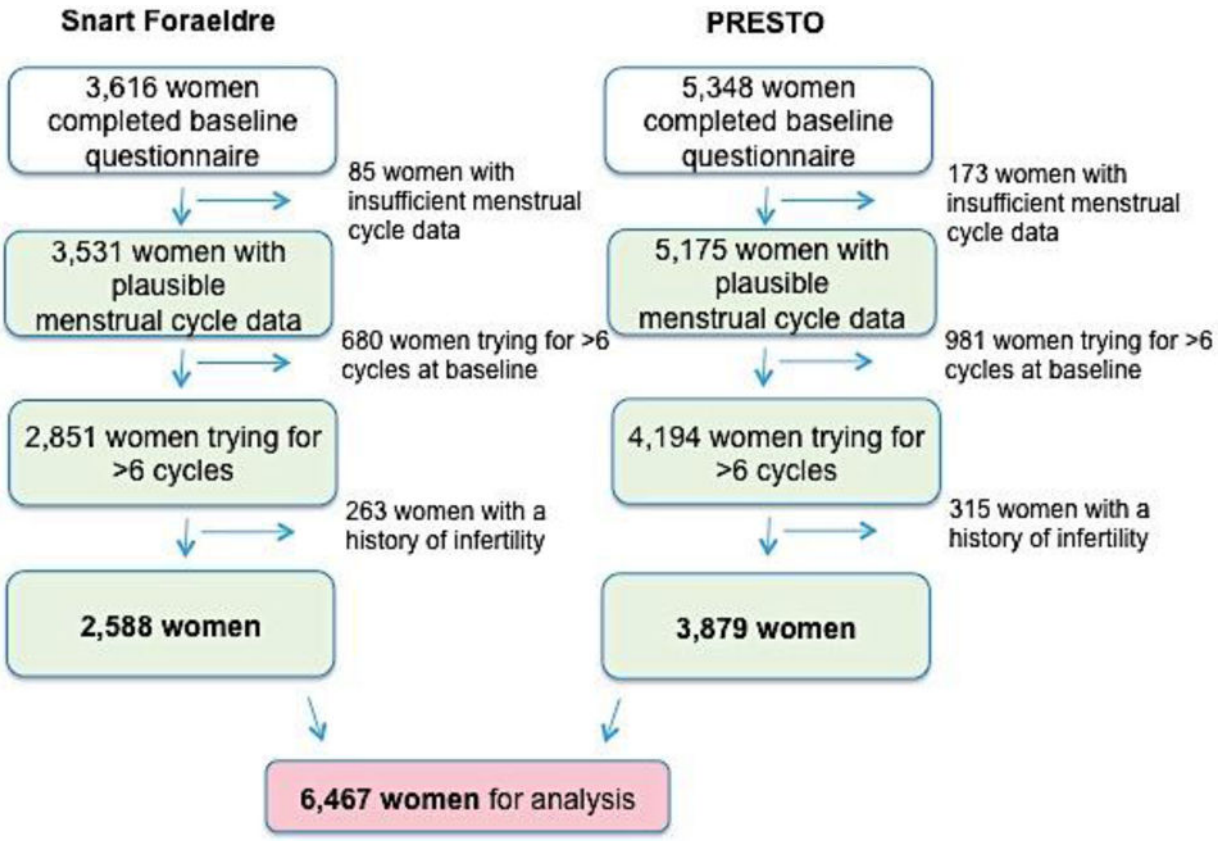

Figure 1.
Flow chart of enrollment and exclusions, Snart Foraeldre and PRESTO (N=8,964), 2011-2017.

Table 1

Baseline characteristics of pregnancy planners by type of lubricant use, Snart Foraeldre and PRESTO (N=6,467), 2011-2017.

	Non-user	User	Water-based/not pH balanced	Water-based/pH balanced	Silicone-based	Oil-based	Mix of types
Number of participants, N (%)	5,337 (82.5)	1,130 (17.5)	737 (11.4)	249 (3.9)	37 (0.6)	69 (1.1)	38 (0.6)
Snart Foraeldre, N (%)	2,288 (42.7)	300 (26.6)	233 (31.6)	13 (5.7)	27 (71.5)	16 (24.2)	11 (34.7)
PRESTO, N (%)	3,049 (57.3)	830 (73.5)	504 (68.4)	236 (94.3)	10 (28.5)	53 (75.8)	27 (65.3)
Pregnancy attempt time at study entry (cycles), mean	2.0	1.9	1.7	2.7	1.1	1.6	2.1
Age (years), %							
<25	13.5	10.3	11.5	8.4	5.4	7.3	7.9
25-29	41.6	41.6	41.8	39.0	54.1	44.9	36.8
30-34	33.3	38.7	38.4	42.2	35.1	34.8	31.6
35-39	10.2	8.9	7.9	9.6	5.4	11.6	21.1
≥40	1.4	0.6	0.4	0.8	0.0	1.5	2.6
Male partner's age (years), mean	31.3	31.3	31.2	31.2	30.9	31.7	32.3
Non-Hispanic white, %	91.1	90.3	91.7	87.7	94.7	86.2	81.3
Annual household income <50,000 USD/300,000 DKK per year), %	18.0	14.6	15.8	13.1	6.2	13.2	10.0
<College degree, %	22.6	19.4	18.9	23.0	13.8	18.8	15.8
BMI (kg/m^2), mean	25.7	25.4	25.3	25.8	23.1	25.4	24.9
Past smoker, %	19.1	16.9	16.3	17.5	25.7	16.0	15.6
Current smoker, %	8.7	4.8	5.4	4.4	6.5	4.1	0.0
Parous, %	29.7	25.2	27.2	19.5	19.8	26.8	18.8
Gravid, %	46.5	40.9	40.7	43.3	36.0	36.5	34.8
Intercourse frequency <1 time/week, %	17.4	21.7	24.1	14.7	27.4	20.3	27.4
Intercourse frequency ≥4 time/week, %	17.9	13.4	12.6	15.2	11.5	14.6	11.8
Doing something to improve chances of conception, %	73.3	76.8	70.5	96.2	68.2	87.6	59.7

USD=U.S. dollars, DKK=Danish kroner

[a]All characteristics except for age are age-standardized to the cohort at baseline.

Table 2

Lubricant use and fecundability among pregnancy planners, Snart Foraeldre and PRESTO (N=6,467), 2011-2017.

Type of Lubricant	No. of Cycles	No. of Pregnancies	Adjusted FR (95% CI)[a]	Adjusted FR (95% CI)[b]
Non-user	20,135	3,335	Reference	Reference
Any lubricant	4,203	724	1.06 (0.99-1.14)	1.04 (0.97-1.12)
Water-based/not PH balanced	2,840	481	1.02 (0.93-1.11)	1.02 (0.93-1.11)
Water-based/pH balanced	914	143	1.11 (0.95-1.30)	1.01 (0.86-1.18)
Silicone-based	107	31	1.35 (0.99-1.84)	1.27 (0.93-1.73)
Oil-based	200	43	1.31 (1.01-1.71)	1.23 (0.94-1.61)
Mix of types	142	26	1.07 (1.72-1.60)	1.18 (0.79-1.77)

FR=fecundability ratio

[a] Models adjusted for cohort.

[b] Models adjusted for cohort, age, education, non-Hispanic white, household income, BMI, smoking, intercourse frequency, and doing something to improve chances of conception.

Table 3

Lubricant use and fecundability among pregnancy planners stratified by age, parity, and cohort (Snart Foraeldre and PRESTO) (N=6,467), 2011-2017.

Exposure	No. of Cycles	No. of Pregs	Adjusted FR (95% CI) [a]	Adjusted FR (95% CI) [b]	No. of Cycles	No. of Pregs	Adjusted FR (95% CI) [a]	Adjusted FR (95% CI) [b]
	PRESTO				**Snart Foraeldre**			
Non-user	12,059	1,797	Reference	Reference	8,076	1,538	Reference	Reference
Any lubricant	3,243	496	1.01 (0.92-1.10)	0.98 (0.89-1.07)	960	228	1.18 (1.04-1.34)	1.16 (1.02-1.31)
Water-based/not PH balanced	2,075	303	0.95 (0.85-1.06)	0.95 (0.84-1.06)	765	178	1.14 (0.99-1.32)	1.13 (0.97-1.31)
Water-based/pH balanced	875	135	1.08 (0.92-1.27)	0.97 (0.82-1.14)	39	8	1.53 (0.82-2.83)	1.44 (0.78-2.67)
Silicone-based	34	9	1.28 (0.71-2.33)	1.19 (0.66-2.15)	73	22	1.38 (0.96-1.98)	1.28 (0.89-1.83)
Oil-based	143	32	1.40 (1.03-1.89)	1.28 (0.95-1.74)	57	11	1.11 (0.66-1.87)	1.07 (0.63-1.80)
Mix of types	116	17	0.92 (0.59-1.44)	1.06 (0.68-1.66)	26	9	1.44 (0.68-3.01)	1.41 (0.67-3.00)
	Age <30 years				**Age ≥30 years**			
Non-user	10,835	1,854	Reference	Reference	9,300	1,481	Reference	Reference
Any lubricant	2,118	392	1.10 (0.99-1.21)	1.08 (0.98-1.20)	2,085	332	1.02 (0.92-1.14)	1.00 (0.90-1.12)
Water-based/not PH balanced	1,436	263	1.06 (0.94-1.20)	1.06 (0.94-1.20)	1,404	218	0.97 (0.85-1.10)	0.97 (0.85-1.11)
Water-based/pH balanced	441	76	1.18 (0.95-1.46)	1.11 (0.89-1.37)	473	67	1.05 (0.84-1.31)	0.92 (0.73-1.15)
Silicone-based	67	17	1.21 (0.79-1.87)	1.19 (0.77-1.83)	40	14	1.58 (1.03-2.44)	1.44 (0.93-2.23)
Oil-based	115	22	1.14 (0.79-1.66)	1.04 (0.72-1.52)	85	21	1.55 (1.07-2.23)	1.55 (1.07-2.22)
Mix of types	59	14	1.24 (0.72-2.14)	1.32 (0.76-2.30)	83	12	0.95 (0.55-1.62)	1.09 (0.63-1.88)
	Nulliparous				**Parous**			
Non-user	15,024	2,238	Reference	Reference	5,111	1,097	Reference	Reference
Any lubricant	3,282	516	1.08 (0.99-1.18)	1.06 (0.97-1.16)	921	208	1.05 (0.92-1.19)	1.01 (0.88-1.15)
Water-based/not PH balanced	2,174	329	1.02 (0.91-1.14)	1.03 (0.92-1.15)	555	152	1.02 (0.88-1.19)	1.01 (0.87-1.17)
Water-based/pH balanced	754	115	1.17 (0.98-1.39)	1.07 (0.90-1.28)	160	28	0.99 (0.70-1.41)	0.82 (0.58-1.16)
Silicone-based	98	24	1.28 (0.88-1.87)	1.20 (0.83-1.75)	9	7	2.04 (1.40-2.97)	1.88 (1.27-2.80)
Oil-based	147	31	1.42 (1.04-1.94)	1.34 (0.98-1.85)	53	12	1.08 (0.67-1.74)	0.95 (0.60-1.52)
Mix of types	109	17	1.06 (0.66-1.68)	1.13 (0.70-1.82)	33	9	1.11 (0.50-2.47)	1.33 (0.57-3.11)

FR=fecundability ratio

[a] Models adjusted for cohort.

[b] Models adjusted for cohort, age, education, non-Hispanic white, household income, BMI, smoking, intercourse frequency, and doing something to improve chances of conception.