**Human Reproduction, Vol.32, No.6 pp. 1325–1333, 2017**
Advanced Access publication on April 7, 2017 doi:10.1093/humrep/dex065

human reproduction

**ORIGINAL ARTICLE** ***Reproductive epidemiology***

# Transitions in pregnancy planning in women recruited for a large prospective cohort study

**U. Luderer[1,*], T. Li[2], J.P. Fine[3], R.F. Hamman[4], J.B. Stanford[5], and D. Baker[1]**

[1]Division of Occupational and Environmental Medicine, Department of Medicine, University of California Irvine, Irvine, CA 92617, USA [2]Westat, Rockville, MD 20850, USA [3]Department of Biostatistics, University of North Carolina Gillings School of Public Health, Chapel Hill, NC 27599, USA [4]Department of Epidemiology, Colorado School of Public Health, Aurora, CO 80045, USA [5]Department of Family and Preventive Medicine, University of Utah, Salt Lake City, UT 84108, USA

*Correspondence address. Center for Occupational and Environmental Health, 100 Theory Drive, Suite 100, Irvine, CA 92617, USA. Tel: +1-949-824-8641; Fax: +1-949-824-2345; E-mail: uluderer@uci.edu

*Submitted on November 10, 2015; resubmitted on February 10, 2017; accepted on March 21, 2017*

**STUDY QUESTION:** Do the rates at which women transition among different intensities of pregnancy planning vary with age, marital status and race/ethnicity?

**SUMMARY ANSWER:** Rates of transition from low or moderate pregnancy probability groups (PPGs) to higher PPGs vary by age, marital status and race/ethnicity.

**WHAT IS KNOWN ALREADY:** The design of prospective studies of the effects of pre- and peri-conception exposures on fecundity, pregnancy and children's health is challenging because at any specific time only a small percentage of reproductive age women is attempting to conceive. To our knowledge, there has been no population-based, prospective study that repeatedly assessed pregnancy planning, which included women who were not already planning pregnancy at enrollment and whose ages spanned the female reproductive age range.

**STUDY DESIGN, SIZE, DURATION:** A longitudinal study was carried out that repeatedly assessed pregnancy probability in 12 916 women for up to 21 months from January 2009 to September 2010.

**PARTICIPANTS/MATERIALS, SETTING, METHOD:** We analyzed data from the National Children's Study Vanguard Study, a pilot study for a large-scale epidemiological birth cohort study of children and their parents. During the Vanguard Study, investigators followed population-based samples of reproductive age women in each of seven geographically dispersed and diverse study locations over time to identify when they sought to become pregnant, providing a unique opportunity to prospectively assess changes in pregnancy planning in a large sample of US women. At study entry and each follow-up contact, which occurred at 1, 3 or 6 month intervals depending on PPG, a questionnaire was used to assess behavior dimensions of pregnancy planning to assign women to low, moderate, high non-tryer and high tryer PPGs.

**MAIN RESULTS AND THE ROLE OF CHANCE:** Crude rates of pregnancy increased with higher assigned PPG, validating the utility of the instrument. The initial PPG and probabilities of transitioning from low or moderate PPG to higher PPG or pregnancy varied with age, marital status and race/ethnicity. Women aged 25 to <35 years had shorter times to transition to higher PPGs or to pregnant compared with women <25 years. Women who were not currently married had longer times to transition from any initial PPG to pregnant, high tryer or high non-tryer status than currently married women. Non-Hispanic Black (NHB) and Hispanic women had shorter time to transition from low or moderate to high non-tryer than non-Hispanic White (NHW) women. NHB women also had shorter time to transition from low to high tryer than NHW women. High tryers are more likely to be aged 25 to <30 years, to be married, and to be Hispanic, NHB or other race/ethnicity than women in the low PPG.

**LIMITATIONS, REASONS FOR CAUTION:** Loss to follow-up varied by age, marital status and race/ethnicity. Although weights were not developed for the Vanguard study, the self-weighting design minimizes the bias of unweighted analysis. Nonetheless, the SEs for some estimates may be under-estimated.

**WIDER IMPLICATIONS OF THE FINDINGS:** Our results show that demographic characteristics are strong predictors of women's behaviors toward pregnancy. The results further show that frequent follow-up assessments of pregnancy planning behavior in large numbers of women are required to recruit an unbiased sample of preconception women. These findings will be useful to investigators designing prospective studies of fecundability, pregnancy outcomes and children's health.

**STUDY FUNDING/COMPETING INTERESTS:** National Institutes of Health (contracts N01-HD53414, N01-HD63416, N01-HD53410, N01-HD53415, N01-HD53396, N01-HD53413 and N01-HD-53411; grant R21 ES016846) and by the University of California Irvine Center for Occupational and Environmental Health. No competing interests.

**TRIAL REGISTRATION NUMBER:** None.

**Key words:** pregnancy planning / probability of pregnancy / prospective study / unplanned pregnancy / pregnancy behavior / competing risks

# Introduction

In order to study the effects of pre- and peri-conception exposures on fecundity, pregnancy and children's health, prospective study designs are valuable to minimize potential measurement biases that may be associated with retrospective study designs. Such prospective studies of fecundity and early pregnancy necessitate recruiting women prior to conception (Buck *et al.*, 2004; Chapin *et al.*, 2004). In most cases, women enrolled in preconception studies are those who intend to become pregnant. At any given time, these women represent a minority of women of reproductive potential (Keiding *et al.*, 2002). Therefore, knowledge about the rates of transitioning among different intensities of pregnancy intention and pregnancy planning and the factors that modify those rates is critical to evaluating the feasibility of prospective preconception enrollment in population-based studies. However, to our knowledge, there have been no population-based prospective studies that repeatedly assessed pregnancy intention or planning including women who were not already planning pregnancy at enrollment and whose ages spanned the female reproductive age range.

Pregnancy desire, intention and planning are related, but not synonymous; further they are not binary phenomena, but exist on a spectrum (Trussell *et al.*, 1999; Klerman, 2000; Stanford *et al.*, 2000; Morin *et al.*, 2003; Barrett *et al.*, 2004; Mumford *et al.*, 2016). Pregnancy desire has been defined as 'a feeling that does not necessarily lead to action'; pregnancy intention as a state of mind highly associated with contextual factors, and pregnancy planning as 'adoption of active behavior centered on conception' (Stanford *et al.*, 2000; Morin *et al.*, 2003). Attitudes of women toward pregnancy planning vary by age, ethnicity, education, marital status and socioeconomic status (Wilson and McQuiston, 2006; Lifflander *et al.*, 2007; Phipps and Nunes, 2012). Most births occurring outside marriage are not intended. In the USA, 65% of births to unmarried women not living with a partner have been reported to be unintended (Wildsmith *et al.*, 2011; Mosher *et al.*, 2012). More recent analyses of data from the National Survey on Family Growth concluded that 57% of births to unmarried women cohabiting with a partner and 28% of births to married women were unintended; however, relaxing the assumptions for birth control use, reasons for non-use and pregnancy timing decreased the percentages of unintended pregnancies among cohabiting and married women to 51 and 23%, respectively (Mumford *et al.*, 2016). Rates of birth outside marriage differ greatly by race, ethnicity and education of the mother. It was found that 73% of US non-Hispanic black (NHB), 53% of Hispanic and 29% of non-Hispanic White (NHW) children were born outside marriage (Wildsmith *et al.*, 2011). For NHW women aged 20–30 years with no college education, 51% of births occurred outside marriage, compared with 34% for NHW women with some college education and 8% for NHW women with a college degree (Wildsmith *et al.*, 2011). However, the impacts of demographic and socioeconomic factors on transitions in pregnancy intention, planning and probability have been only minimally investigated. Understanding how sociodemographic factors affect pregnancy planning over time is important to better target counseling and education about family planning and peri-conception preventive measures. Such data may also help us understand the reasons for the very high rates of unintended pregnancies among US women. Finally, such data are critically needed to inform the design of prospective studies in which preconception enrollment is required, and in particular, prospective studies of time to pregnancy.

The National Children's Study (NCS) Vanguard Study was a pilot study for a large-scale birth cohort study of children and their parents (Montaquila *et al.*, 2010; Baker *et al.*, 2014; Stanford *et al.*, 2015). Measures were to be taken from pre-pregnancy until the children reached adulthood. Ultimately, the National Institutes of Health decided to cancel the program before full implementation. Nonetheless, data from the Vanguard Study can be used to address a number of research questions in reproductive, perinatal, pediatric and environmental health. Investigators enrolled and followed population-based samples of reproductive age women in several study locations to identify when they sought to become pregnant. Probability of pregnancy was prospectively categorized based on questions that assessed reproductive behavior and pregnancy planning. We hypothesized that rates of transition from lower levels of pregnancy probability to higher levels would vary by race/ethnicity, age and marital status.

# Materials and Methods

## Sampling

Details of the NCS initial sampling strategy have been previously reported (Montaquila *et al.*, 2010; Baker *et al.*, 2014; Stanford *et al.*, 2015). Briefly, a self-weighting geographically based cluster probability sample was carried out in which primary sampling units (PSUs) were US counties, clusters of small population counties or sub-divisions of very large population

counties. From 110 sampled PSUs, 7 PSUs were selected for the initial Vanguard Study to include different census regions and different population sizes (Queens County, NY; Montgomery County, PA; Waukesha County, WI; Brookings County, SD and Yellow Medicine, Pipestone, and Lincoln counties, MN; Orange County, CA; Salt Lake County, UT; Duplin County, NC). Within each PSU, smaller geographic areas based on contiguous census blocks were selected as the secondary sampling units (SSU), using a stratified random sampling scheme with the measure of size being the estimated annual number of births in each SSU. Initially, each center was expected to recruit enough women to yield 250 births/year from each PSU. However, as changes were made to the overall plan of the NCS, recruitment efforts *via* these Vanguard Centers were reduced and then discontinued within 2 years.

## Enumeration, eligibility screening and enrollment

Enumeration, screening for eligibility and enrollment began in January 2009 for two centers, with implementation in all centers by May 2009. The primary means of recruiting eligible women was by door-to-door contact at all residences within each SSU. Data collectors enumerated all persons living in each household, based on one adult informant.

Women of reproductive age living in the household were screened for eligibility *via* a 'pregnancy screener', which included a computer-assisted self-interview that addressed pregnancy, sexual activity, birth control use and history of infertility or sterility. Informed consent for the pregnancy screener was obtained verbally at the time it was administered. Written informed consent for enrollment of eligible women was obtained during in-person visits either at the time of enumeration or during a follow-up visit scheduled for enrollment. When enrollment began, women who were pregnant were eligible for the study; later, women at high probability of pregnancy were also eligible. Details of enrollment have been reported elsewhere (Baker *et al.*, 2014); this manuscript focuses on the women who were not pregnant at initial screening and were then followed for their probability of pregnancy.

## Ethical approval

The study protocols were approved by the Institutional Review Boards of all of the participating institutions.

## Initial pregnancy screening and follow-up

The initial pregnancy screener asked about current or probable pregnancy and date of the last menstrual period. Pregnant women were classified as 'pregnant eligible' or 'holding' depending on their due dates; for the purposes of the present manuscript, both of these groups were combined into one 'pregnant' group. For women who were not pregnant, the screener included questions that assessed pregnancy planning and behavior, but did not assess pregnancy intention (Morin *et al.*, 2003; Barrett *et al.*, 2004; NCS, 2009). An algorithm used the answers to the questions to assign women to low, moderate, high non-tryer or high tryer pregnancy probability groups (PPGs; Supplementary Figure S1). The algorithm is summarized in Table I.

Women who were not currently pregnant and not sterile were asked for permission to be followed with periodic telephone calls. Frequency of follow-up varied according to their expected probability of becoming pregnant. The high tryer and high non-tryer PPG women were contacted 1, 2 and 4 months after being so identified. After preconception enrollment of women in the high PPGs started, women in those groups who were being followed by telephone were enrolled directly into the study before becoming pregnant. Moderate PPG women were contacted every 3 months, and low PPG women were contacted every 6 months from May to December 2009 and every 3 months thereafter. The follow-up questions and algorithms (Supplementary Figures S2–S4) were similar to the initial pregnancy screener. Based on responses to the questions at each follow-up, women could remain in the same PPG, move to a different PPG, or be identified as pregnant.

**Table I Summary of criteria for initial PPG assignments.**

| Initial PPG | Criteria for PPG assignment |
|---|---|
| Low | Using a contraceptive method other than withdrawal or natural family planning AND age 30–44 years OR trying to conceive for ≥12 months OR trying to conceive for 5–11 months AND age 35–49 years OR (not trying to conceive OR don't know) AND (not surgically sterile OR menopausal) AND (age 45–49 years OR had not had sex with a male in the past 3 months OR partner had a vasectomy) |
| Moderate | Using a contraceptive method other than withdrawal or natural family planning AND age 18–29 years OR trying to conceive for 5–11 months AND age 18–34 years OR had sex with a male within 3 months, age 35–44 years AND (not using any contraception OR using withdrawal OR natural family planning) |
| High non-tryer | Had sex with a male within 3 months, age 18–34 years and (not using any contraception OR using withdrawal OR natural family planning) |
| High tryer | Trying to conceive for <5 months |

PPG, pregnancy probability group.

After 4 months in either of the high PPGs without pregnancy, women were transitioned by protocol to the moderate PPG. Starting in June 2010, the follow-up telephone pregnancy screener was simplified to remove questions about birth control use or sexual activity, and women were classified as high probability of pregnancy only if they indicated they were currently trying to become pregnant and for <5 months (i.e. only 'high tryers' were considered high PPG; 'high non-tryers' were no longer identified). The 5-month cut-off was chosen because most pregnancies in couples who are actively trying to conceive occur within the first 4–6 months of trying (Gnoth *et al.*, 2003). Data for this report are based on follow-up from January 2009 to September 2010.

## Statistical analyses

Descriptive statistics were used to show demographic characteristics and initial PPG of women who had at least one successful follow-up compared with those who had none; crude rates of specific first PPG transitions per 100 person-months of follow-up; number of PPG transitions by initial PPG; and transitions from initial PPG by demographic characteristics. Although weights were not developed for the Vanguard study, the self-weighting design minimizes the bias of unweighted analysis. Nonetheless, the standard errors for some estimates may be under-estimated by ignoring the sample clustering (Kish, 1965).

We conducted multinomial logistic regression analyses of the initial PPG with age, race/ethnicity and marital status as predictors and low PPG as referent.

Survival models were used to analyze the length of time until the first PPG transition. Person-time for each participant was calculated from the date of initial screening to the first PPG transition or, if no transitions, to the last follow-up contact or the end of Vanguard Study follow-up in September 2010. These models used only data from participants who had

one or more successful follow-up contacts. The observed time-to-transition was considered as interval censored because the precise timing of any transition within each interval between follow-ups was not known, and the time interval between assessments was not constant. Also because each woman could transition to multiple different PPGs at each follow-up contact (e.g. a moderate PPG woman could transition to any other PPG), a 'competing risks' model was considered to be appropriate. Therefore, we applied interval censored models using the naïve likelihood method for competing risks (Hudgens *et al.*, 2014) to analyze the associations of age, race/ethnicity and marital status with the probabilities of transition. This method uses parametric accelerated failure time models for the cumulative incidence functions fit separately to each transition (Jeong and Fine, 2007). We explored multiple parametric distributions available based on the fitting statistics Akaike's Information Criterion and Bayesian Information Criterion. The log-normal distribution provided a good fit for all of the transitions, except for the moderate to low transition, for which the log-logistic distribution provided the best fit and was used for this transition. We calculated the relative length of time to transition using exp($\beta$) where $\beta$ represents the model regression coefficient.

As a sensitivity analysis for violation of distribution assumptions, we also implemented a semiparametric model (Fine and Gray, 1999) and compared the parameter estimates from both sets of models. The parameter estimates were generally consistent. More information about the statistical models is provided in Supplementary Data and Supplementary Tables SVII–SIX.

# Results

## Demographic characteristics and initial PPG by follow-up status

Table II shows demographic characteristics and initial PPG of all women in the cohort who were not pregnant at screening, but eligible for follow-up, divided into those who had at least one successful follow-up after initial screening and those who had none. About one-third of the initial 20 087 women had no successful follow-up contacts. Table II shows that women 44 years of age or older had a lower rate of follow-up than younger women. NHB, non-Hispanic Asian (NHA)

**Table II Demographics and initial PPG of non-pregnant and eligible women in the recruitment database.**

| Demographic characteristics of 20 087 women | At least one successful follow-up | | No successful follow-up | |
|---|---|---|---|---|
| | Number | Percentage[b] | Number | Percentage[b] |
| Total | 12 916 | | 7171 | |
| Age at initial pregnancy screen (years)[a] | | | | |
| <25 | 3369 | 26.1 | 1695 | 23.6 |
| 25 to <30 | 2245 | 17.4 | 1139 | 15.9 |
| 30 to <35 | 2064 | 16.0 | 1025 | 14.3 |
| 35 to <44 | 3619 | 28.2 | 1942 | 27.1 |
| ≥44 | 1573 | 12.2 | 1335 | 18.6 |
| Missing[c] | 46 | 0.35 | 35 | 0.5 |
| Race/Ethnicity[a] | | | | |
| White, Non-Hispanic | 9226 | 71.4 | 4522 | 63.1 |
| Black, Non-Hispanic | 532 | 4.1 | 464 | 6.5 |
| Asian, Non-Hispanic | 928 | 7.2 | 678 | 9.5 |
| Hispanic | 1727 | 13.4 | 1159 | 16.2 |
| Other | 378 | 2.9 | 275 | 3.8 |
| Missing[c] | 125 | 1.0 | 73 | 1.0 |
| Marital status[a] | | | | |
| Divorced | 605 | 4.7 | 459 | 6.4 |
| Never married | 4559 | 35.3 | 2649 | 36.9 |
| Married | 7421 | 57.5 | 3750 | 52.3 |
| Separated | 165 | 1.3 | 194 | 2.7 |
| Widowed | 38 | 0.3 | 43 | 0.6 |
| Missing[c] | 128 | 1.0 | 76 | 1.1 |
| Initial PPG status[a] | | | | |
| Low | 7504 | 58.1 | 4927 | 68.7 |
| Moderate | 3907 | 30.3 | 1777 | 24.8 |
| High non-tryer | 1072 | 8.3 | 372 | 5.2 |
| High tryer | 433 | 3.4 | 95 | 1.3 |

[a]*P*-value (Chi-square test) <0.001.
[b]Percentages may not add to 100 due to rounding.
[c]Includes missing, refused and do not know.

**Table III Sociodemographic characteristics associated with initial PPG among women not pregnant at initial screening (low PPG is referent).**[a]

| Demographic characteristics | Moderate OR (95% CI) | High non-tryer OR (95% CI) | High tryer OR (95% CI) |
|---|---|---|---|
| Age at initial pregnancy screen (years) | | | |
| ≤25 | 1.0 | 1.0 | 1.0 |
| 25 to <30 | 1.51 (1.32–1.74) | 1.93 (1.58–2.36) | 1.94 (1.38–2.74) |
| ≥30 to <35 | 0.01 (0.01–0.02) | 0.47 (0.38–0.59) | 0.39 (0.28–0.56) |
| ≥35 | 0.06 (0.05–0.07) | NA | 0.09 (0.06–0.13) |
| Marital status | | | |
| Currently married | 1.0 | 1.0 | 1.0 |
| Never married | 0.38 (0.33–0.43) | 0.34 (0.28–0.41) | 0.11 (0.08–0.15) |
| Divorced or separated | 0.59 (0.47–0.74) | 0.69 (0.50–0.95) | 0.49 (0.31–0.76) |
| Widowed | 0.91 (0.36–2.29) | NA | NA |
| Race/Ethnicity | | | |
| White, Non-Hispanic | 1.0 | 1.0 | 1.0 |
| Black, Non-Hispanic | 1.14 (0.90–1.45) | 2.33 (1.70–3.18) | 2.77 (1.80–4.27) |
| Asian, Non-Hispanic | 0.78 (0.65–0.94) | 1.09 (0.83–1.43) | 1.08 (0.74–1.57) |
| Hispanic | 1.30 (1.14–1.50) | 1.96 (1.63–2.35) | 1.42 (1.07–1.89) |
| Other | 1.16 (0.88–1.51) | 2.22 (1.56–3.16) | 1.91 (1.13–3.23) |

[a]Multinomial logistic regression analysis. OR, odds ratio.

and Hispanic women had lower rates of follow-up than NHW women, and divorced, never married and separated women had lower rates of follow-up than married women. Women whose initial PPG was low were less likely to have a successful follow-up than women whose initial PPG was moderate, high non-tryer or high tryer.

## Demographic correlates of initial PPG status

The associations of age, marital status and race/ethnicity with the initial PPGs for all eligible women are shown in Table III. Women in the 25 to <30 years age groups were significantly more likely to have an initial PPG of moderate, high non-tryer or high tryer than <25-year-old women, while women in the older age groups were significantly less likely to have these initial PPGs than <25 year olds. Never married and divorced/separated women were significantly less likely to have an initial PPG of moderate, high non-tryer and high tryer than currently married women. Hispanic, NHB and non-Hispanic other women were significantly more likely to have an initial PPG of high non-tryer and high tryer than NHW women.

## General characteristics of transitioning participants and rates of first transitions

The number of participants with 0 to >3 PPG transitions is shown by initial PPG in Supplementary Table S1. Overall, participants with moderate initial PPG were about twice (63%) as likely as those with low initial PPG (36%) to have at least one transition during follow-up, while 85% of women initially in the high non-tryer and 90% of women initially in the high tryer groups had at least one transition. Because of the low numbers of women having ≥2 transitions, we focused on the first PPG transition per woman for our subsequent analyses. Women initially in the low and moderate groups had longer follow-up times (306 and 272 days on average, respectively), than women initially in the high non-tryer, high tryer and pregnant groups (160, 147 and 120 days, respectively). This is not surprising because women in the latter groups were more likely to become eligible to be enrolled in the study or to have protocol-forced transitions to moderate after 4 months.

Supplementary Table SII shows the PPG transitions from initial status by age, marital status and race/ethnicity. Among initial moderate PPG women, those aged 30 to <35 years were more likely than other ages to have transitions during follow-up, while among initial low PPG women, those aged 25 to <30 years were more likely than other ages to have transitions during follow-up. Among initial moderate PPG women, those who were currently married were more likely than those not currently married to have transitions.

The crude rates of transition among PPGs for the first transition are shown in Table IV. High tryers had the highest rates of transition to pregnant, followed by high non-tryers, moderate and low in that order. Women initially in the moderate group transitioned to high tryer and high non-tryer at higher rates than women initially in the low PPG. The high rates of transitioning to moderate from the high non-tryer and high tryer groups result to an unknown extent from protocol-forced transitions after 4 months in either of the high PPGs, rather than true changes in pregnancy planning/behavior. Therefore, our subsequent analyses of the associations of demographic variables with PPG transitions examined all transitions for women with initial PPG of low or moderate, who comprised 89% of the women with follow-up data and only transitions to pregnant for women with initial status of high non-tryer or high tryer.

## Influence of demographic characteristics on transition probabilities by initial PPG

The associations between demographic variables and the relative length of time to first transition from low to other PPGs are shown in

**Table IV Crude rates per 100 person-months of follow-up and counts of having specific first PPG status transitions by initial PPG**

| Initial PPG status | Total person time (months) | First transition: Low | | Moderate | | High non-tryer | | High tryer | | Pregnant | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rate | *N* | Rate | *N* | Rate | *N* | Rate | *N* | Rate | *N* |
| Low | 70 624 | NA | 4825 | 3.20 | 2263 | 0.20 | 144 | 0.16 | 116 | 0.22 | 156 |
| Moderate | 27 869 | 6.78 | 1890 | NA | 1451 | 0.71 | 197 | 0.70 | 194 | 0.63 | 175 |
| High non-tryer[a] | 4897 | 2.90 | 142 | 12.72 | 623 | NA | 157 | 1.35 | 66 | 1.72 | 84 |
| High tryer[a] | 1929 | Red[b] | Red[b] | 13.53 | 261 | 0.00 | 0 | NA | 44 | 6.48 | 125 |

NA: transition rate not applicable because there was no PPG status change.
[a]All high non-tryers and high tryers were automatically moved to moderate if they did not become pregnant within 4 months.
[b]Redacted because the *N* per group was below National Children's Study disclosure avoidance threshold.

**Table V Associations of demographic variables with probability of first transitions from low PPG**

| Demographic subgroup | Low to moderate TTx[a] (95% CI) | Low to high non-tryer TTx (95% CI) | Low to high tryer TTx (95% CI) | Low to pregnant TTx (95% CI) |
|---|---|---|---|---|
| Age <25 years | 1.00 | *1.00* | 1.00 | 1.00 |
| 25 to <30 years | 1.03 (0.93,1.14) | 0.52 (0.22,1.24) | 0.27 (0.07,1.00) | 0.19 (0.05,0.67) |
| 30 to <35 years | 1.46 (1.35,1.58) | 0.68 (0.31,1.45) | 0.18 (0.06,0.62) | 0.19 (0.06,0.57) |
| ≥35 years | 1.28 (1.19,1.38) | Estimate not stable | 1.81 (0.58,5.69) | 1.70 (0.59,4.92) |
| Currently married | 1.00 | 1.00 | 1.00 | 1.00 |
| Not currently married | 0.99 (0.94,1.05) | 3.23 (1.59,6.57) | 5.35 (2.27,12.59) | 6.41 (2.89,14.22) |
| Non-Hispanic White | 1.00 | 1.00 | 1.00 | 1.00 |
| Hispanic | 1.08 (1.01,1.16) | 0.23 (0.11,0.49) | 1.65 (0.69,3.96) | 0.54 (0.29,1.02) |
| Black | 1.20 (1.06,1.36) | 0.12 (0.10,0.38) | 0.17 (0.06,0.48) | 2.79 (0.48,16.25) |
| Asian | 1.07 (0.98,1.16) | 0.23 (0.10,0.55) | 0.62 (0.27,1.42) | 3.04 (0.96,9.59) |
| Other | 1.15 (1.00,1.32) | 0.78 (0.15,4.15) | 0.46 (0.13,1.67) | 1.59 (0.32,7.99) |

[a]TTx = Fold change in length of time to transition (ratio of length of time to transition) relative to reference group.

Table V. These results show that for low initial PPG women, those aged 30 to <35 years and ≥35 years of age had significantly longer times to transition to moderate than women aged <25 years. Women in the 25 to <35 years age group had shorter times to transition to high non-tryer, high tryer or pregnant than women in the <25 years age group. These estimates were quite precise, with narrow CIs. In contrast, the estimates for the relative times to transition from low to high non-tryer, high tryer and pregnant for women ≥35 years of age were wide and most included 1.0. Among the initially low PPG women, not being currently married was associated with significantly longer times to transition to high non-tryer, high tryer and pregnant, compared with being currently married. In contrast, the coefficient for marital status for the transition from low to moderate was not statistically significant. Compared with NHW women, the NHB, Hispanic and other race/ethnicity women had significantly longer times to transition from low to moderate. Compared with NHW women, the NHB, Hispanic and NHA race/ethnicity women had significantly shorter times to transition from low to high non-tryer. For the transition from low to high tryer, NHB women had a significantly shorter time to transition than NHW women. The coefficients for race/ethnicity for the other transitions were not statistically significant.

Supplementary Table SIII shows the cumulative probabilities of first transition from low PPG directly to pregnant within subgroups defined by the covariates (age, race/ethnicity, marital status) calculated using the fitted multivariate regression models. The cumulative probabilities were calculated from the cumulative function for log-normal distributions, using the estimated regression coefficients for covariates and the scale parameter. This table shows that the highest probabilities of first transition from low to pregnant occurred for Hispanic, aged 25 to <35 years, currently married women (4.8% probability of first transition

**Table VI Associations of demographic variables with probability of first transitions from moderate PPG**

| Demographic subgroup | Moderate to low TTx[a] (95% CI) | Moderate to high non-tryer TTx (95% CI) | Moderate to high tryer TTx (95% CI) | Moderate to pregnant TTx (95% CI) |
|---|---|---|---|---|
| Age <25 years | 1.00 | 1.00 | 1.00 | 1.00 |
| 25 to <30 years | 1.05 (0.98,1.12) | 1.50 (0.91,2.47) | 0.40 (0.24,0.66) | 0.75 (0.45,1.24) |
| 30 to <35 years | 1.49 (1.11,2.01) | estimate not stable | 0.17 (0.05,0.62) | 0.02 (0.01,0.08) |
| ≥35 years | 0.65 (0.59,0.79) | 108.6 (19.4,552.0) | 0.99 (0.52,1.80) | 3.42 (1.62,7.20) |
| Currently married | 1.00 | 1.00 | 1.00 | 1.00 |
| Not currently married | 0.83 (0.79,0.89) | 1.49 (0.90,2.47) | 5.58 (3.27,9.53) | 4.18 (2.43,7.21) |
| Non-Hispanic White | 1.00 | 1.00 | 1.00 | 1.00 |
| Hispanic | 0.87 (0.81,0.93) | 0.50 (0.27,0.93) | 0.77 (0.45,1.31) | 0.55 (0.32,0.96) |
| Black | 0.89 (0.77,1.02) | 0.12 (0.05,0.33) | 0.55 (0.20,1.49) | 5.89 (0.72,48.05) |
| Asian | 0.80 (0.71,0.89) | 0.64 (0.22,1.85) | 2.17 (0.82,5.74) | 1.75 (0.61,5.02) |
| Other | 0.96 (0.83,1.12) | 0.51 (0.14,1.82) | 0.42 (0.15,1.18) | 5.28 (0.61,45.59) |

[a]TTx = Fold change in length of time to transition relative to reference group.

pregnancies per 90 days of follow-up). The probabilities in this table and in Supplementary Table SIV should not be interpreted as incidence rates. They represent probabilities based on absolute risk from the competing risk models.

The associations between demographic variables and the relative length of time to first transition from moderate to other PPGs are shown in Table VI. Times to transition from moderate to other PPGs varied significantly by age. Women aged 30 to <35 years had shorter times to transition from moderate to high tryer or pregnant and longer times to transition from moderate to low compared with women aged <25 years. The coefficients for age for the other transitions were not statistically significant or had extremely wide CIs. Not being currently married was significantly associated with a shorter time to transition from moderate to low and longer times to transition from moderate to high tryer and pregnant compared with being currently married. The CIs for marital status for the transition from moderate to high non-tryer included 1.0. NHB and Hispanic women had a significantly shorter time to transition from moderate to high non-tryer than NHW women. Hispanic women had a significantly shorter time to transition from moderate to pregnant compared with NHW women. The estimates for race/ethnicity for the other transitions were not statistically significant.

Supplementary Table SIV shows the cumulative probabilities of first transition from moderate PPG directly to pregnant within subgroups defined by the covariates (age, race/ethnicity, marital status) calculated using the fitted multivariate regression models. This table shows that the highest probabilities of first transition from moderate to pregnant occurred for Hispanic, aged 30 to <35 years, currently married women, followed by White, aged 30 to <35 years, currently married women.

The associations between demographic variables and the probabilities of transitioning from high non-tryer to pregnant are shown in Supplementary Table SV. Not being currently married was associated with a significantly longer time to transition from high non-tryer to pregnant. Women in the 30 to <35 years age group had significantly longer time to transition from high non-tryer to pregnant than women in the <25 years age group.

The associations between demographic variables and the probabilities of transitioning from high tryer to pregnant are shown in Supplementary Table SVI. Not being currently married was associated with significantly longer time to transition from high tryer to pregnant compared with being currently married.

## Discussion

We found that women assigned to different PPGs based on their responses to a few questions about pregnancy planning and behavior had rates of transitioning to pregnancy that increased from the low to the high tryer PPG. Initial PPG and the transition from one initial PPG to another were significantly associated with age, race/ethnicity and marital status.

Some women transitioned directly from low or moderate PPG to pregnant apparently without first transitioning to one of the high PPGs, at very similar rates as those at which women transitioned to either of the high PPGs (Table IV). This may be related to the relatively infrequent follow-up. Alternatively, it may be because the pregnancy screener questions did not address changes in pregnancy intention. If the goal is to enroll women prior to conception for a prospective study of fecundability (time to pregnancy), then being able to capture a change from not intending pregnancy to intending pregnancy, as well as from being at low probability of pregnancy to being at high probability of pregnancy, is of critical importance. This could be achieved by recruiting women at low and moderate probabilities of pregnancy and following them frequently with an instrument designed to measure pregnancy planning, as well as intention (Morin *et al.*, 2003; Barrett *et al.*, 2004). Our results indicate that this would require following large numbers of women for relatively long periods of time because the rates of transition from low or moderate to high non-tryer, high tryer, or pregnant were all less than one per 100 person-months of

follow-up overall. Our results will be helpful to determine which demographic subgroups should be followed more frequently because they have high probabilities of transitioning to pregnant from low or moderate (Supplementary Tables SIII and SIV).

For studies of pregnancy outcomes in which preconception or very early postconception exposures are of interest, our data show that an efficient recruitment strategy might focus on women identified as high tryers, as they were nearly four times as likely to become pregnant as their first transition as high non-tryers and >29 times as likely as low PPG women (Table IV). Consistent with the latter, another recent paper estimated the cumulative probabilities of pregnancy at 1 year (not just at first transition) in the same cohort of women and found that these were 56% for high non-tryers and 86% for high tryers (Baker *et al.*, 2014; Stanford *et al.*, 2015). It should be noted that the rates in Table IV are likely lower than the true rates because of non-response and transition out of PPG follow-up into the active study for some high PPG women. These results validate the instrument's ability to sort women into groups with different probabilities of pregnancy. However, a strategy limited to high tryers could be less representative of the population because our data also show that high tryers differ from other women in that they are more likely to be aged 25 to <30 years, to be married, and to be Hispanic, NHB, or other race/ethnicity than women in the low PPG. Alternatively if the objective is to study the postconception prenatal period, random sampling of prenatal care providers and recruiting women from those providers may offer a relatively non-biased, but still efficient, approach to prenatal recruitment of women early in pregnancy.

The baseline percentage of high tryers in our study is consistent with other studies that found that ~2–4% of reproductive age women were actively trying to become pregnant (Schwarz *et al.*, 2007; Buck Louis *et al.*, 2013; Moreau *et al.*, 2013). In the latter two studies, ~75–90% of women said that they were trying to avoid pregnancy and ~10–22% had ambivalent attitudes toward pregnancy (Schwarz *et al.*, 2007; Moreau *et al.*, 2013). Ambivalence was associated with younger age, not being currently married, non-White race/ethnicity and not working full time (Schwarz *et al.*, 2007). Our low and moderate PPGs do not correspond exactly with the trying to avoid pregnancy and ambivalent groups in the study by Schwarz *et al.* (2007) because of the different questions used. Nonetheless, we found that age, marital status and race/ethnicity were significant predictors of initial PPG status. Other studies that examined women's attitudes toward pregnancy used populations that were likely enriched in women with positive or negative attitudes (Crosby *et al.*, 2002; Kavanaugh and Schwarz, 2009). Therefore, direct comparisons of percentages of women who were trying to become pregnant or trying to avoid pregnancy in those studies with ours are not appropriate.

We have previously reported that ~3.5% of the participants eligible for follow-up at baseline screening were known to become pregnant over the course of follow-up though September 2012 when the Vanguard study ended (Baker *et al.*, 2014; Stanford *et al.*, 2015). The present study shows that age, marital status and race/ethnicity were all significant predictors of initial PPG and of the probability of transitioning from the initial PPG to other PPGs. Consistent with demographic trends toward women delaying childbirth to older ages, we found that women aged 25 to <35 years had shorter times to transition to higher PPGs or to pregnant compared with women <25 years. Women who were not currently married had longer times to transition from any initial PPG to pregnant, high tryer or high non-tryer status than currently married women. These results show that marital status remains a strong predictor of women's attitudes and behavior toward pregnancy despite rising rates of birth outside marriage over the past four decades in the USA (Wildsmith *et al.*, 2011). NHB and Hispanic women had shorter time to transition from low or moderate to high non-tryer than NHW women. NHB women also had shorter time to transition from low to high tryer than NHW women. The latter findings are consistent with higher birth rates among Hispanic and NHB women compared with NHW women (Martin *et al.*, 2015)

The study has several strengths and limitations. Strengths of the study include the population-based sample, large number of participants and repeated ascertainment of PPG. A limitation of the study is that participants who had no follow-up differed from those with at least one successful follow-up by age, marital status and race/ethnicity. Even though the differences were statistically significant, the distributions of those lost to follow-up versus those with at least one follow-up did not vary much in terms of absolute proportions by age, ethnicity/race or marital status (Table II). Moreover, the demographic variables were adjusted for in the models, so loss to follow-up would not have affected our conclusions about the associations of these variables with PPG transitions. These differences in loss to follow-up do however have implications for the design of birth cohort studies. Another limitation of the study results from various protocol-forced transitions, such as the transition from high non-tryer or high tryer to moderate after 5 months without conception and transitions from high tryer to moderate and moderate to low with increasing age from 34 to 35 years and with increasing duration of trying. Unfortunately, the data set did not permit us to distinguish true (in terms of pregnancy planning and behavior) from protocol-forced transitions. All of the transitions that are affected by this limitation are transitions from a higher to a lower PPG. Therefore, we have greater confidence in the conclusions drawn from the models for transitions from lower to higher PPG.

In summary, an instrument containing questions that assess pregnancy behavior and planning was used to assign women to different PPGs. Crude rates of pregnancy increased with increasing assigned PPG, validating the utility of the instrument. The initial PPG and rates of transitioning from initial PPG of low or moderate to other PPGs varied with age, marital status and race/ethnicity, showing that these demographic variables are strong predictors of women's attitudes and behaviors toward pregnancy. The analyses further showed that frequent follow-up assessments of pregnancy planning in large numbers of women are required to recruit an unbiased sample of preconception women. These findings may be useful to investigators designing prospective studies of fecundability, pregnancy outcomes and children's health.

# Supplementary data

Supplementary data are available at *Human Reproduction* online.

# Acknowledgements

The authors thank all of the participants in the NCS Vanguard Study without whom this study would not have been possible. This manuscript, a primary NCS publication, was developed by a Writing Team assembled by the NCS Publications Committee for the purpose of timely sharing of centrally collected NCS data.

## Authors' roles

U.L. and D.B. contributed to study conception and design. T.L. analyzed data. J.P.F. advised on analytical methods. U.L. drafted manuscript. All authors contributed to interpretation of data and editing manuscript. All authors approved the final manuscript.

## Funding

The analysis was conducted as part of the National Children's Study, supported by the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development, and funded, through its appropriation, by the Office of the Director of the National Institutes of Health (contracts N01-HD-53414, N01-HD-63416, N01-HD-53410, N01-HD-53415, N01-HD-53396, N01-HD-53413 and N01-HD-53411). Additional funding was provided by NIH R21 ES016846 to U.L. and by the University of California Irvine Center for Occupational and Environmental Health (D.B. and U.L.).

## Conflict of interest

The authors declare that they have no conflicts of interest.

## References

Baker D, Park C, Sweeney C, McCormack L, Durkin M, Brenner R, Dabelea D, Entwisle B. Recruitment of women in the National Children's Study Initial Vanguard Study. *Am J Epidemiol* 2014;**179**:1366–1374.

Barrett G, Smith SC, Wellings K. Conceptualisation, development, and evaluation of a measure of unplanned pregnancy. *J Epidemiol Community Health* 2004;**58**:426–433.

Buck GM, Lynch CD, Stanford JB, Sweeney AM, Schieve LA, Rockett JC, Selevan SG, Schrader SM. Prospective pregnancy study designs for assessing reproductive and developmental toxicants. *Environ Health Perspect* 2004;**112**:79–86.

Buck Louis GM, Sundaram R, Schisterman EF, Sweeney AM, Lynch CD, Gore-Langton RE, Maisog J, Kim S, Chen Z, Barr DB. Persistent environmental pollutants and couple fecundity: the LIFE study. *Environ Health Perspect* 2013;**121**:231–236.

Chapin RE, Robbins WA, Schieve LA, Sweeney AM, Tabacova SA, Tomashek KM. Off to a good start: the influence of pre- and periconceptional exposures, parental fertility, and nutrition on children's health. *Environ Health Perspect* 2004;**112**:69–78.

Crosby RA, DiClemente RJ, Wingood GM, Davies SL, Harrington K. Adolescents' ambivalence about becoming pregnant predicts infrequent contraceptive use: a prospective analysis of nonpregnant African American females. *Am J Obstet Gynecol* 2002;**186**:251–252.

Fine JP, Gray RJ. A proportional hazards model for the subdistribution of a competing risk. *J Am Stat Assoc* 1999;**94**:496–509.

Gnoth C, Godehardt D, Godehardt E, Frank-Hermann P, Freundl G. Time to pregnancy: results of the German prospective study and impact on the management of fertility. *Hum Reprod* 2003;**18**:1959–1966.

Hudgens MG, Li C, Fine JP. Parametric likelihood inference for interval censored competing risks data. *Biometrics* 2014;**70**:1–9.

Jeong J-H, Fine JP. Parametric regression on cumulative incidence function. *Biometrics* 2007;**8**:184–196.

Kavanaugh ML, Schwarz EB. Prospective assessment of pregnancy intentions using a single- versus a multi-item measure. *Perspect Sex Reprod Health* 2009;**41**:238–243.

Keiding N, Kvist K, Hartvig H, Tvede M, Juul S. Estimating time to pregnancy from current durations in a cross-sectional sample. *Biostatistics* 2002;**3**:565–578.

Kish L. *Survey Sampling*. New York: Wiley, 1965.

Klerman LV. The intendedness of pregnancy: a concept in transition. *Matern Child Health J* 2000;**4**:155–162.

Lifflander A, Gaydos LMD, Rowland Hogue CJ. Circumstances of pregnancy: low income women in Georgia describe the difference between planned and unplanned pregnancies. *Matern Child Health J* 2007;**11**:81–89.

Martin JA, Hamilton BE, Osterman MJK, Curtin SC, Mathews TJ. Births: final data for 2013. *Natl Vital Stat Rep* 2015;**64**:1–68.

Montaquila JM, Brick JM, Curtin LR. Statistical and practical issues in the design of a national probability sample of births for the Vanguard Study of the National Children's Study. *Stat Med* 2010;**29**:1368–1376.

Moreau C, Hall K, Trussell J, Barber J. Effect of prospectively measured pregnancy intentions on the consistency of contraceptive use among young women in Michigan. *Hum Reprod* 2013;**28**:642–650.

Morin P, Payette H, Moos M-K, St-Cyr-Tribble D, Niyonsenga T, De Wals P. Measuring the intensity of pregnancy planning effort. *Paediatr Perinat Epidemiol* 2003;**17**:97–105.

Mosher WD, Jones J, Abma JC. Intended and unintended births in the United States: 1982–2010. *Natl Health Stat Rep* 2012;**55**:1–28.

Mumford SL, Sapra KJ, King RB, Louis JF, Buck Louis GM. Pregnancy intentions - a complex construct and call for new measures. *Fertil Steril* 2016;**106**:1453–1462.

NCS. 2009 Study Center Call Center Interviewer Training. https://ncsarchive.s-3.net/bioshare/study_documents/

Phipps MG, Nunes AP. Assessing pregnancy intention and associated risks in pregnant adolescents. *Matern Child Health J* 2012;**16**:1820–1827.

Schwarz EB, Lohr PA, Gold MA, Gerbert B. Prevalence and correlates of ambivalence towards pregnancy among nonpregnant women. *Contraception* 2007;**75**:305–310.

Stanford JB, Brenner R, Fetterer D, Palmer L, Schoendorf KC. Impact of preconception enrollment on birth enrollment and timing of exposure assessment in the initial vanguard cohort of the U.S. National Children's Study. *BMC Med Res Methodol* 2015;**15**:75.

Stanford JB, Hobbs R, Jameson P, DeWitt MJ, Fischer RC. Defining dimensions of pregnancy intendedness. *Matern Child Health J* 2000;**4**:183–189.

Trussell J, Vaughan B, Stanford JB. Are all contraceptive failures unintended pregnancies? *Fam Plann Perspect* 1999;**31**:246–247&260.

Turnbull BW. The empirical distribution function with arbitrarily grouped, censored and truncated data. *J R Stat Soc Ser B* 1976;**38**:290–295.

Wildsmith E, Steward-Streng NR, Manlove J. Childbearing outside of marriage: estimates and trends in the United States. In: *Child Trends Research Brief*. Washington, DC: Child Trends, 2011. Document 2011–29.

Wilson EK, McQuiston C. Motivations for pregnancy planning among Mexican immigrant women in North Carolina. *Matern Child Health J* 2006;**10**:311–320.