Breastfeeding, Childhood Milk Consumption, and Onset of Puberty

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KEY WORDS
Child, cohort studies, breastfeeding, milk, puberty

ABBRVIATIONS
CI—confidence interval
SEP—socioeconomic position
SHS—Student Health Service
TR—time ratio

Dr Kwok performed the literature review, conducted data analysis, interpreted findings, and drafted the manuscript; Dr Schooling conceptualized ideas, designed and directed analytic strategy, interpreted findings, revised drafts of the manuscript, and supervised the study from conception to completion; Dr Lam initiated Hong Kong’s “Children of 1987” birth cohort; Drs Schooling and Leung resurrected the birth cohort; and all authors revised the manuscript critically for important intellectual content and finally approved the version to be published.

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WHAT’S KNOWN ON THIS SUBJECT: Early life nutrition may program pubertal timing. Limited evidence suggests breastfeeding is associated with later puberty and childhood milk consumption with earlier puberty, whether these observations are biologically mediated or confounded by socioeconomic position is unclear.

WHAT THIS STUDY ADDS: In a developed non-Western setting with little socioeconomic patterning of pubertal timing, neither breastfeeding nor childhood milk consumption was associated with pubertal timing, suggesting nutritional exposures during potentially critical periods may not have long-term effects on rates of maturation.

abstract

OBJECTIVE: Early nutrition has been postulated as programming pubertal timing. Limited observational studies, mainly from Western settings, suggest pubertaly occurs later with breastfeeding and earlier with higher cow’s milk (including infant formula) consumption. However, these observations may be socioeconomically confounded. This study examined whether breastfeeding or childhood milk consumption was associated with pubertal onset in a setting with different associations of breastfeeding and puberty with socioeconomic position.

METHODS: The adjusted associations of breastfeeding or milk consumption at 6 months, 3 years, and 5 years with clinically assessed age at pubertal onset (Tanner stage II) were assessed by using interval-censored regression in a population-representative Hong Kong Chinese birth cohort, “Children of 1997,” with 90% follow-up (N = 7523).

RESULTS: Compared with never breastfeeding, exclusive breastfeeding for 3+ months was unrelated to age at pubertal onset (time ratio [TR] 1.001, 95% confidence interval [CI] 0.987–1.015), as was partial breastfeeding for any length of time or exclusive breastfeeding for <3 months (TR 1.003, 95% CI 0.996–1.010), adjusted for gender, socioeconomic position, birth weight-for-gestational age, birth order, second-hand smoke exposure, and mother's age and place of birth. Daily milk consumption at 6 months (TR 1.004, 95% CI 0.991–1.018), 3 years (TR 0.995, 95% CI 0.982–1.008), or 5 years (TR 0.998, 95% CI 0.988–1.009) was also unrelated to age at pubertal onset compared with milk consumption for ≤1 time per week at the corresponding ages.

CONCLUSIONS: In a non-Western setting, neither breastfeeding nor childhood milk consumption was associated with age at pubertal onset, suggesting that associations may vary by setting. PEDIATRICS 2012;130:e631–e639
Early puberty is associated with hormone-related cancers and cardiovascular disease.\(^1\) Determinants of pubertal timing are not well understood, although the reduction in age at puberty with economic development suggests an environmental, potentially modifiable, component.\(^2\) Infancy could be a sensitive period for determining pubertal timing. First, exposures during the “mini-puberty” of infancy may determine the subsequent reawakening of the gonadotropic axis at puberty by affecting early development of the hypothalamic-pituitary-adrenal axis.\(^3\) Second, pubertal timing may represent a life history strategy for reproductive success, whereby developmental plasticity enables differing investments in greater growth or earlier maturity depending on environmental cues during fetal and infant life.\(^4\) Breastfeeding represents a key modifiable exposure during infancy, which could influence pubertal timing. Similarly, childhood cow’s milk consumption has also been suggested as affecting puberty\(^5,6\), specific nutrients in milk such as animal protein,\(^7\) animal fat,\(^7\) and calcium\(^8\) have been linked with earlier puberty.

To date, earlier menarche has been found associated with formula feeding (including mixed feeding) in a small cross-sectional study from Hawaii\(^9\) and with earlier introduction of formula feeding in a prospective birth cohort from the Philippines.\(^10\) Conversely, in a small cohort from Germany, full breastfeeding at 4 months was not associated with age at the pubertal growth spurt, peak height velocity, or menarche,\(^11\) while duration of breastfeeding was not associated with age at menarche in a small cohort from the United Kingdom.\(^12\) One large population-based cross-sectional study in the United States found greater quantity, but not frequency, of childhood milk consumption was associated with earlier menarche,\(^13\) whereas another similarly large cross-sectional study in Turkey found frequency of milk consumption not associated with menarche.\(^14\) Observational studies are open to unmeasured or uncontrollable residual confounding, because many exposures and health attributes are socially patterned, of which contextually specific findings may be an indicator. Hong Kong provides an economically developed non-Western setting to verify potentially confounded associations. In Hong Kong, pubertal timing is unrelated to family socioeconomic position (SEP),\(^15\) reducing confounding by SEP. Moreover, breastfeeding is also not clearly associated with higher SEP as often occurs in Western settings. In Hong Kong, more educated mothers tend to start but not sustain breastfeeding, whereas migrant mothers tend to start and sustain breastfeeding.\(^16\) Cow’s milk–based formula is usually used; soy-based formula is only recommended where medically indicated.\(^17\) In contrast, milk consumption in Hong Kong is socially patterned; children with more educated mothers consume more milk.\(^18\) However, the range of milk consumption is wider in Hong Kong than in most other developed settings; it is normal in Hong Kong for children to eschew milk because it is not part of a traditional Chinese diet and lactose persistence is uncommon.\(^19\) Moreover, most previous studies have examined the association of breastfeeding with age at menarche, which occurs toward the end of puberty, represents a composite of timing and duration of puberty, and is specific to girls. To provide a distinction between these processes and to consider a similar marker in both genders, we examined the association of breastfeeding and childhood milk consumption with the age at pubertal onset in both genders by using a large, population-representative non-Western birth cohort, Hong Kong’s “Children of 1997.” We also examined whether the associations varied by gender, birth order, or mother’s place of birth.

**METHODS**

**Data Source**

Hong Kong’s “Children of 1997” birth cohort\(^20\) is a population-representative Chinese birth cohort (\(N = 8327\)) that covered 88.0% of all births from April 1, 1997, to May 31, 1997. The study was initially established to investigate the effect of second-hand smoke exposure on infant health. Families were recruited at the first postnatal visit to any of the 49 Maternal and Child Health Centers in Hong Kong, which all parents of newborns are encouraged to attend. Characteristics obtained by using a self-administered questionnaire in Chinese at recruitment and subsequent routine visits included maternal and birth characteristics, family socioeconomic position, and early life exposures, such as breastfeeding. Passive follow-up via record linkage was instituted in 2005 to obtain routinely collected information including biannual pubertal status from grade 2 onward from the Student Health Service (SHS), Department of Health, which provides free annual check-ups for all school students, and death records from the Death Registry. Active follow-up via direct contact was instituted in 2007. A postal survey (Survey I) including questions on milk drinking was sent in July 2008, then re-sent a second and third time as necessary over the following 9 months.

Of the original 8327 cohort members, as of August 31, 2011, 26 had permanently withdrawn. Of the remaining 8301, 7936 were potentially contactable in 2008–2009 to participate in Survey I, while 75 had migrated without trace, 278 were untraceable (probably migrated or dead), and 12 were known to be dead. Of these 7936, 3679 responded to Survey I, of whom 98.2% provided information on milk drinking. The 3679 respondents
feeding, as previously,22 using a rela-
spondent was asked:

duration perhaps because of short

Exposures
The primary exposures were breast-

Outcomes
The outcome was age at pubertal onset,

Statistical Analysis
To show the age distribution of pubertal

and 4257 nonrespondents to Survey I
(including 324 who declined to partici-
pate, 3401 who did not reply, and 532
who have not yet been contacted) were
similar in breastfeeding (Cohen effect
size = .16), gender, birth weight, birth
order, and key sociodemographic at-
tributes, such as mother’s place of birth,
parents’ education, parents’ occupation,
and household income (Cohen effect
sizes all <.2).21

Exposures
The primary exposures were breast-
 feeding and childhood milk consump-
tion (at about 6 months, 3 years, and 5
years). Information on breastfeeding
was obtained from self-administered
questionnaires completed mainly by
mothers at the first (generally shortly
after birth) and subsequent (at about 3,
9, and 18 months) routine visits to the
Maternal and Child Health Centers.
At the first visit, the respondent was
asked: “How is the infant currently fed?”
specified as “exclusively breastfed,”
“partially breastfed,” and “only for-

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Maternal and Child Health Centers.
At the first visit, the respondent was
asked: “How is the infant currently fed?”
specified as “exclusively breastfed,”
“partially breastfed,” and “only for-

Outcomes
The outcome was age at pubertal onset,
as the earliest age when Tanner stage II
for breast (girls) or genitalia (boys) was
recorded. Currently, there is a lack of
standardization as to the first sign of
male pubertal development (genital
stage II or testicular volume of 4 mL).24
Most reports have used genital stage II,
but increasingly testicular volume is
used as the indicator of male pubertal
development. Initial analysis found sim-
ilar association with either definition
(genital stage II or testicular volume
of 4 mL), so we used genital stage II
for consistency with previous reports.
Pubertal status was visually assessed
by physicians at the SHS according to
the criteria of Marshall and Tanner in
grades 1, 3, 5, and 7 (i.e., usually at 6–7
years, 8–9 years, 10–11 years, and 12–13
years, respectively). Children with
infeasible sequences of pubertal stages,
such as pubertal stage II before puber-
tal stage I (22 girls and 32 boys), were
excluded.

Statistical Analysis
To show the age distribution of pubertal
onset, we show the cumulative pro-
portion with pubertal onset before each
age in years from 7 to 14 years. We used
multivariable interval-censored re-
gression, with a log-normal distribution,
to examine the adjusted associations
of the exposures with age at pubertal
onset, from which time ratios (TRs)
with 95% confidence intervals (CIs) are
presented. A TR greater than 1 indicates
older age at pubertal onset, while a TR
less than 1 indicates younger age at
pubertal onset. As the exact age at
pubertal onset was not precisely ob-
served, interval-censored regression
provides a means for using the age
interval within which a child experi-
cenced pubertal onset. Each child was
censored in 1 of 3 ways: (1) left cen-
soring if the child had experienced
pubertal onset by the first examination
date, (2) interval censoring if the child
had pubertal onset between 2 exami-
nation dates, and (3) right censoring if
the child had not experienced pubertal
onset by the most recent examination
date. We also used interval-censored
regression to assess the unadjusted
association of gender with age at pu-
bertal onset, from which estimated
mean age at pubertal onset with 95%
CIs were obtained for boys and girls.
We assessed whether the associations
varied with gender or birth order or
mother’s place of birth from the het-
rogeneity of effect across strata and
Missing values were imputed based on a flexible additive regression model with predictive mean matching incorporating data on the outcome (maximum age at Tanner stage I and minimum age at Tanner stage II), exposures (breastfeeding and childhood milk consumption), potential confounders, and infant residency. We summarized the results from 10 imputed datasets into single estimated β-coefficients with CIs adjusted for missing data uncertainty. We also performed an available case analysis (ie, deleting cases with missing data on variables in an analysis-by-analysis basis) for comparison. Statistical analyses were performed by using Stata version 10 (Stata Corp, College Station, TX) and R version 2.12.1 (R Development Core Team, Vienna, Austria).

**Ethics Approval**

The study obtained ethical approval from the University of Hong Kong-Hospital Authority Hong Kong West Cluster Joint Institutional Review Board.

**RESULTS**

Of the 7523 cohort members (3540 girls and 3983 boys, 90% follow-up rate) with information on age at pubertal onset, 76.1% of the girls had onset of breast development and 41.9% of the boys had onset of genitalia development before age of 14 years (Table 1). About 10% of girls had onset of breast development before age of 9 years. In boys, onset of genital development was closely synchronized with that of testicular development (testicular vol of 4 mL). Pubic hair development was a later sign of pubertal onset for both girls and boys. Among girls, estimated mean age at onset of breast development was 9.6 years, and among boys, mean age at onset of genital development was 11.7 years and mean age of testicular development was 11.4 years, similar to a recent population-representative survey in Hong Kong. During infancy, 57.0% were never breastfed, 36.6% were partially breastfed for any length of time or exclusively breastfed for <3 months, and 6.4% were exclusively breastfed for 3+ months. At ~6 months, 8.9% consumed cow’s milk or milk powder 1 time per week or less often, 2.5% consumed 2 to 6 times per week, and 88.6% consumed daily; the corresponding proportions at 3 years were 15.9%, 16.1%, and 68.0%, and at 5 years, were 33.6%, 21.2%, and 45.2%.

Table 2 shows that cohort members from families of higher SEP were more likely to be partially breastfed for any length of time or exclusively breastfed for less than 3 months, while those from families of lower SEP were more likely to be exclusively breastfed for 3+ months. Those with mothers born in

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**TABLE 1** Cumulative Proportion With Pubertal Onset Before Each Age (y), Assessed From Breast, Pubic Hair, Genitalia or Testicular Development, by Gender in 7523 Children From Hong Kong’s “Children of 1987” Birth Cohort

<table>
<thead>
<tr>
<th>Age, y</th>
<th>Girls (n = 3540)</th>
<th>Boys (n = 3983)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Breast Tanner Stage ≥ II</td>
<td>Pubic Hair Tanner Stage ≥ II</td>
</tr>
<tr>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>&lt;7</td>
<td>15</td>
<td>0.4</td>
</tr>
<tr>
<td>&lt;8</td>
<td>41</td>
<td>1.2</td>
</tr>
<tr>
<td>&lt;9</td>
<td>355</td>
<td>10.0</td>
</tr>
<tr>
<td>&lt;10</td>
<td>853</td>
<td>24.1</td>
</tr>
<tr>
<td>&lt;11</td>
<td>1738</td>
<td>49.0</td>
</tr>
<tr>
<td>&lt;12</td>
<td>2279</td>
<td>64.4</td>
</tr>
<tr>
<td>&lt;13</td>
<td>2467</td>
<td>69.7</td>
</tr>
<tr>
<td>&lt;14</td>
<td>2694</td>
<td>76.1</td>
</tr>
</tbody>
</table>
## TABLE 2 Baseline Characteristics by Breastfeeding and Milk Consumption Frequency at Different Ages in 7523 Children From Hong Kong’s “Children of 1997” Birth Cohort

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>No.</th>
<th>%</th>
<th>Breastfeeding</th>
<th>Milk Consumption at 6 mo</th>
<th>Milk Consumption at 3 y</th>
<th>Milk Consumption at 5 y</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Never</td>
<td>Partially Breastfed</td>
<td>Exclusively Breastfed</td>
<td>Daily</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>for Any Length of Time or Exclusively Breastfed for ≤3 mo,</td>
<td>n = 4287</td>
<td>n = 480</td>
<td>n = 869</td>
</tr>
<tr>
<td>Child’s gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>3540</td>
<td>47.1</td>
<td>46.8</td>
<td>46.2</td>
<td>54.0</td>
<td>48.7</td>
</tr>
<tr>
<td>Male</td>
<td>3983</td>
<td>52.9</td>
<td>53.2</td>
<td>53.8</td>
<td>46.0</td>
<td>48.8</td>
</tr>
<tr>
<td>Birth weight-for-gestational age z-score&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7523</td>
<td>100.0</td>
<td>0.08 (0.98)</td>
<td>0.06 (0.91)</td>
<td>0.06 (0.96)</td>
<td>0.05 (0.99)</td>
</tr>
<tr>
<td>Birth order</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>3577</td>
<td>47.5</td>
<td>44.2</td>
<td>53.9</td>
<td>41.4</td>
<td>42.0</td>
</tr>
<tr>
<td>2</td>
<td>3126</td>
<td>41.6</td>
<td>44.0</td>
<td>37.6</td>
<td>42.6</td>
<td>44.2</td>
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<tr>
<td>≥3</td>
<td>820</td>
<td>10.9</td>
<td>11.9</td>
<td>8.5</td>
<td>16.0</td>
<td>13.8</td>
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<tr>
<td>Second-hand smoke exposure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>2085</td>
<td>27.4</td>
<td>26.3</td>
<td>28.5</td>
<td>31.8</td>
<td>30.3</td>
</tr>
<tr>
<td>Nonparental household smoking</td>
<td>2838</td>
<td>37.7</td>
<td>35.4</td>
<td>42.4</td>
<td>31.7</td>
<td>30.9</td>
</tr>
<tr>
<td>Paternal smoking</td>
<td>2252</td>
<td>29.9</td>
<td>31.9</td>
<td>26.1</td>
<td>34.6</td>
<td>32.7</td>
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<tr>
<td>Maternal smoking</td>
<td>370</td>
<td>4.9</td>
<td>6.5</td>
<td>3.0</td>
<td>19.0</td>
<td>6.1</td>
</tr>
<tr>
<td>Mother’s age at birth, y</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤24</td>
<td>915</td>
<td>12.2</td>
<td>12.7</td>
<td>11.2</td>
<td>13.1</td>
<td>15.5</td>
</tr>
<tr>
<td>25–29</td>
<td>2354</td>
<td>31.3</td>
<td>31.5</td>
<td>30.2</td>
<td>35.8</td>
<td>31.7</td>
</tr>
<tr>
<td>30–34</td>
<td>2892</td>
<td>38.4</td>
<td>37.7</td>
<td>40.6</td>
<td>33.1</td>
<td>35.9</td>
</tr>
<tr>
<td>≥35</td>
<td>1362</td>
<td>18.1</td>
<td>18.2</td>
<td>18.0</td>
<td>18.0</td>
<td>17.0</td>
</tr>
<tr>
<td>Mother’s place of birth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mainland China or elsewhere</td>
<td>2819</td>
<td>38.8</td>
<td>35.5</td>
<td>38.3</td>
<td>71.1</td>
<td>55.6</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>4604</td>
<td>61.2</td>
<td>64.5</td>
<td>61.7</td>
<td>28.9</td>
<td>44.4</td>
</tr>
<tr>
<td>Parents’ highest education at recruitment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 9</td>
<td>2530</td>
<td>30.8</td>
<td>33.5</td>
<td>24.3</td>
<td>44.2</td>
<td>46.4</td>
</tr>
<tr>
<td>Grades 10–11</td>
<td>3257</td>
<td>43.3</td>
<td>46.4</td>
<td>39.9</td>
<td>35.4</td>
<td>36.1</td>
</tr>
<tr>
<td>Grade ≥12</td>
<td>1946</td>
<td>25.9</td>
<td>20.1</td>
<td>35.8</td>
<td>20.4</td>
<td>17.5</td>
</tr>
<tr>
<td>Parents’ highest occupation at recruitment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I (professional)</td>
<td>1738</td>
<td>23.1</td>
<td>19.2</td>
<td>30.3</td>
<td>17.0</td>
<td>17.9</td>
</tr>
<tr>
<td>II (managerial)</td>
<td>1097</td>
<td>14.6</td>
<td>14.4</td>
<td>15.5</td>
<td>11.0</td>
<td>11.0</td>
</tr>
<tr>
<td>III (nonmanual skilled)</td>
<td>2198</td>
<td>29.2</td>
<td>31.3</td>
<td>27.2</td>
<td>22.4</td>
<td>26.0</td>
</tr>
<tr>
<td>IV (manual skilled)</td>
<td>1401</td>
<td>18.6</td>
<td>20.4</td>
<td>14.6</td>
<td>26.4</td>
<td>24.0</td>
</tr>
<tr>
<td>V (semiskilled)</td>
<td>804</td>
<td>10.7</td>
<td>11.2</td>
<td>9.2</td>
<td>14.5</td>
<td>15.1</td>
</tr>
<tr>
<td>VI (unskilled)</td>
<td>285</td>
<td>3.8</td>
<td>3.6</td>
<td>3.2</td>
<td>8.7</td>
<td>6.0</td>
</tr>
</tbody>
</table>

<sup>a</sup> z-score = (birth weight - mean weight at gestational age) / standard deviation weight at gestational age.
Hong Kong were less likely to be ever breastfed than those with mothers born in mainland China, who were also more likely to exclusively breastfeed for 3+ months. Higher family SEP was positively associated with cow’s milk or milk powder consumption at ∼6 months, 3 years, and 5 years.

There was no evidence of heterogeneity across strata by gender, parental age, or mother’s place of birth (P > .15). We did not stratify the analysis. Table 3 shows that neither breastfeeding nor cow’s milk or milk powder consumption at ∼6 months, 3 years, or 5 years was associated with age at pubertal onset, adjusted for gender (model 1), additionally adjusted for parents’ education, occupation, and income (model 2), or further adjusted for birth order (model 3). The available case analysis produced similar results (see Appendix).

**DISCUSSION**

In this large, contemporary population-representative Hong Kong Chinese birth cohort with a high follow-up rate, childhood (cow’s) milk or milk powder consumption at ∼6 months, 3 years, or 5 years was not associated with age at pubertal onset. These findings suggest that breastfeeding or cow’s milk consumption does not play a major role in pubertal timing.

This large birth cohort study, with its strength of high follow-up, contemporaneously collected breastfeeding history, and clinically assessed pubertal onset, nonetheless has several limitations. First, childhood (cow’s) milk consumption was not contemporaneous with high follow-up, containing a prolonged collection of breastfeeding history, and clinically assessed pubertal onset. These findings suggest that breastfeeding or cow’s milk consumption does not play a major role in pubertal timing.

### Table 2

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>No.</th>
<th>%</th>
<th>Breastfeeding</th>
<th>Milk Consumption at 6 mo</th>
<th>Milk Consumption at 3 y</th>
<th>Milk Consumption at 5 y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never Breastfed, n = 4287</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partially Breastfed for Any Length of Time or Exclusively Breastfed for &lt;3 mo, n = 480</td>
<td></td>
<td></td>
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<tr>
<td>Exclusively Breastfed for 3+ mo, n = 480</td>
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<tr>
<td>&lt;1 time/wk, n = 669</td>
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<tr>
<td>2–6 times/wk, n = 191</td>
<td></td>
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<tr>
<td>Daily, n = 663</td>
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<tr>
<td>≤1 time/wk, n = 1199</td>
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<tr>
<td>2–6 times/wk, n = 1210</td>
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<td></td>
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<td></td>
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<tr>
<td>Daily, n = 2528</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤1 time/wk, n = 3403</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2–6 times/wk, n = 1920</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Mean (SD) values instead of column % were presented.*
milk consumption was based on recall, which weakens the study. Second, we do not have information on the total energy intake or type of milk. Hong Kong children mainly consume powdered and fresh milk, low fat or skimmed milk was uncommon a decade ago. Third, we did not have complete information on childhood milk consumption. However, we used multiple imputation to capitalize on all available data while preserving the uncertainty from the missing data, minimizing inclusion bias and increasing statistical power. An available case analysis produced similar results. Fourth, the proportion of children exclusively breastfed was relatively small, which may limit power. However, we have previously observed exclusive breastfeeding associated with serious infectious morbidity, as expected. Fifth, environmental pollutants in breast milk could counteract the beneficial effect of breastfeeding on pubertal timing. However, associations did not vary by birth order when the burden of pollutants in breast milk tends to be greater for the firstborn as a result of maternal lifetime body burden of pollutants. Finally, any random variation in pubertal assessment by different physicians at 12 SHS centers would reduce the precision of estimates. However, a standard guideline for staging and an orchiometer were available and, with our large sample, statistical power is unlikely to have been compromised.

Our findings of no association of breastfeeding or childhood milk consumption with age at pubertal onset replicated some, but not all, observational studies primarily from Western populations. However, these studies are limited by small sample sizes, long-term recall, unclearly defined breastfeeding, cross-sectional designs, lack of dose response, low follow-up rates, and no adjustment for socioeconomic confounding. Children from families of higher SEP may overstate their pubertal development. Longer duration of breastfeeding, lower milk consumption, and later pubertal onset tend to be associated with higher SEP in long-term developed Western countries and lower family SEP in recently developing countries. Conversely, in other recently developed settings such as Hong Kong or in some Western cohorts breastfeeding and puberty have different social patterns. In Hong Kong, there is also a much broader range of milk consumption than in Western countries. Nevertheless, we cannot rule out the possibility that residual confounding by SEP may have generated the particular associations we observed, although the lack of confounding by SEP makes it unlikely (model 2 compared with model 1). Conversely, it is possible that in other settings, residual socioeconomic confounding could have generated a
positive association of breastfeeding or a negative association of childhood milk consumption with puberty. Nevertheless, taken together, these disparate findings suggest that any observed associations of breastfeeding or childhood milk consumption with puberty need to be interpreted with caution.

CONCLUSIONS
Breastfeeding has many infant and maternal benefits and childhood milk consumption is a source of protein and calcium; however, this large, population-representative Chinese birth cohort provides no evidence that these exposures have long-term effects on pubertal timing.

ACKNOWLEDGMENTS
The authors thank colleagues at the SHS and Family Health Service of the Department of Health for their assistance and collaboration. They also thank Dr Connie Hui for her assistance with the record linkage and the late Dr Connie O for coordinating the project and all the fieldwork for the initial study in 1997–1998.

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29. Moons KG, Donders RA, Stijnen T, Harrell FE. Using the outcome for imputation of missing predictor values was preferred. J Clin Epidemiol. 2006;59(10):1087–1091

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### APPENDIX

Available Case Analysis for Adjusted Association of Breastfeeding or Milk Consumption Frequency at Different Ages With Age at Pubertal Onset (Tanner Stage II) From Hong Kong’s “Children of 1997” Birth Cohort

<table>
<thead>
<tr>
<th></th>
<th>Model 1&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Model 2&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Model 3&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>TR</td>
<td>95% CI</td>
</tr>
<tr>
<td><strong>Breastfeeding</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never breastfed</td>
<td>4206</td>
<td>Reference</td>
<td>—</td>
</tr>
<tr>
<td>Partially breastfed for any length of time or exclusively breastfed for &lt;3 mo</td>
<td>2703</td>
<td>1.003</td>
<td>0.996–1.009</td>
</tr>
<tr>
<td>Exclusively breastfed for 3+ mo</td>
<td>471</td>
<td>0.995</td>
<td>0.982–1.009</td>
</tr>
<tr>
<td><strong>Milk consumption at 6 mo</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤1 time/wk</td>
<td>303</td>
<td>Reference</td>
<td>—</td>
</tr>
<tr>
<td>2–6 times/wk</td>
<td>85</td>
<td>1.002</td>
<td>0.988–1.037</td>
</tr>
<tr>
<td>Daily</td>
<td>3043</td>
<td>1.010</td>
<td>0.994–1.027</td>
</tr>
<tr>
<td><strong>Milk consumption at 3 y</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤1 time/wk</td>
<td>534</td>
<td>Reference</td>
<td>—</td>
</tr>
<tr>
<td>2–6 times/wk</td>
<td>542</td>
<td>1.005</td>
<td>0.988–1.022</td>
</tr>
<tr>
<td>Daily</td>
<td>2352</td>
<td>0.994</td>
<td>0.981–1.007</td>
</tr>
<tr>
<td><strong>Milk consumption at 5 y</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤1 time/wk</td>
<td>1128</td>
<td>Reference</td>
<td>—</td>
</tr>
<tr>
<td>2–6 times/wk</td>
<td>730</td>
<td>1.003</td>
<td>0.980–1.016</td>
</tr>
<tr>
<td>Daily</td>
<td>1571</td>
<td>0.995</td>
<td>0.985–1.006</td>
</tr>
<tr>
<td><strong>Cumulative childhood milk consumption</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nondaily at 6 mo</td>
<td>379</td>
<td>Reference</td>
<td>—</td>
</tr>
<tr>
<td>Daily at 6 mo only</td>
<td>784</td>
<td>1.018</td>
<td>1.001–1.036</td>
</tr>
<tr>
<td>Daily at 6 mo and 3 y only</td>
<td>753</td>
<td>1.009</td>
<td>0.992–1.027</td>
</tr>
<tr>
<td>Daily at 6 mo, 3 y, and 5 y</td>
<td>1457</td>
<td>1.006</td>
<td>0.990–1.022</td>
</tr>
</tbody>
</table>

Model 1 adjusted for gender. Model 2 adjusted for gender, socioeconomic position (education, income, occupation). Model 3 adjusted for gender, socioeconomic position (education, income, occupation), maternal characteristics (mother’s age at birth, place of birth), infant characteristics (birth weight-for-gestational age z-score, birth order, second-hand smoke exposure). —, not applicable.
Breastfeeding, Childhood Milk Consumption, and Onset of Puberty
Man Ki Kwok, Gabriel M. Leung, Tai Hing Lam and C. Mary Schooling

Pediatrics; originally published online August 20, 2012;
DOI: 10.1542/peds.2011-3697

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