PLOS ONE

Exposure to sexually explicit media in early adolescence is related to risky sexual behavior in emerging adulthood

Wen-Hsu Lin[1], Chia-Hua Liu[ID][2]*, Chin-Chun Yi[3]

1 Institute of Health and Welfare Policy, School of Medicine, National Yang-Ming University, Taipei, Taiwan, **2** Department of Industrial Economics, College of Business and Management, Tamkang University, New Taipei City, Taiwan, **3** Institute of Sociology, Academia Sinica, Taipei, Taiwan

* cliu.jarhua@gmail.com

Abstract

Background

Sexually explicit media exposure during early adolescence has been found to be associated with risky sexual behavior. However, previous study suffered from methodological issue, such as selection bias. Furthermore, little is known about the effect of multi-modality sexually explicit media exposure on risky sexual behavior, and how this relationship can be applied to non-western societies.

Objectives

This study aimed to improve upon previous studies by using instrumental variable estimation. In addition, this study also included multi-modality of sexually explicit media and three risky sexual behavior measure from a sample of Taiwanese adolescents.

Methods

Participants were recruited from a prospective longitudinal study (Taiwan Youth Project). All were in 7th grade (mean age = 13.3) when the study was initiated in 2000. Sexually explicit media exposure, including ever-exposure and number of modalities exposed to, was measured in wave 2 (8th grade). Risky sexual behavior was measured in waves 8 (mean age = 20.3) and 10 (mean age = 24.3). A two-stage least squares regression was employed, with pubertal timing as the instrumental variable.

Results

About 50% of participants had been exposed to sexual media content by 8th grade, from an average of one modality. Sexually explicit media exposure predicted early sexual debut, unsafe sex, and multiple sexual partners (all: p < .05). Furthermore, exposure to more media modalities increased the likelihood of risky sexual behaviors. However, only the effect on early sexual debut was gender invariant.

Conclusions

Exposure to sexually explicit media in early adolescence had a substantive relationship with risky sexual behavior in the emerging adulthood. Knowledge of this causal like effect provides a basis for building better preventive programs in early adolescence. One prominent way is early education on media literacy, and physicians themselves may need to be familiar with such content to initiate it.

Introduction

Risky sexual behaviors, including early sexual debut, unsafe sex (e.g., inconsistent condom use), and multiple sexual partners (i.e., high partner change rate) [1], have received attention worldwide for their long-term negative impacts [2], particularly health-related, such as acquisition of sexually transmitted infections (STIs) [3], other diseases [4], unintended/teen pregnancy [3–5], and substance use [6]. Adolescents have received particular attention because they are among those most at risk of other STIs (e.g., gonorrhea) in many countries, such as the U.S. [7] and Taiwan [8] and for many parts of the world (e.g., Asia and Africa) they currently experiencing an HIV/AIDS epidemic [9]. Thus, there is a need to understand the early precursors to risky sexual behaviors for early prevention, as one of the best strategies to fight later negative outcomes.

Risky sexual behavior in adolescence is influenced by several important life domains, such as family/parents, peer, and individual factors. For example, several family-related factors, such as harsh parenting [10–11], low parental control [12], and family cohesion [13] have been identified as risk factors for sexual risk taking behavior and the underlying mechanisms are also presented (e.g., low parental control→low impulsive control→risky behavior or early maltreatment→negative emotions→risky behavior). Similarly, other studies argued from different theoretical perspectives and found possible precursors of risky sexual behaviors. For example, problem behavior theory [14] argues problem behaviors tend to cluster; hence, early substance use is highly related to later risky behavior, including risky sexual behaviors [15–16]. Similarly, social control theory [17] argued a lack of social bond (e.g., low school commitment) "releases" an individual for deviance, including risky sexual behaviors [18]. Other factors simply provide opportunities for sexual practice and are related to risky sexual behaviors, such as those in a romantic relationship [15, 19]. While these other factors have been related to risky sexual behaviors, studies have shown even controlling for these important precursors, one particular factor still has a strong relationship with risky sexual behaviors—sexual content in the media or sexually explicit media (SEM) [20–22]. Strasburger et al. [23] concluded sexual content in the media is a significant factor that influences children and teens in sexually-related behaviors, attitudes, and believes. Wright [24] mentioned exposure to SEM makes individuals more likely to change and establish promiscuous sexual attitudes, which are highly related to risky sexual behaviors later in life. Other studies demonstrated exposure to SEM is related to risky sexual behaviors because it changes viewer's attitudes toward sexuality and women [25–26]. As such, one study argued, while the effects of sexual content in the media may be subtle, it is very important to control and measure [27]. Consequently, SEM may be essential when understanding risky sexual behaviors.

While exposure to SEM may make individual vulnerable to future risky sexual behavior, it is more so to adolescents for three reasons. First, SEM is not only prevalent, but is also influential during adolescence [28–30]. For example, Owens et al. [29] argued the proliferation of pornography has "influenced youth culture and adolescent development in unprecedented and

diverse ways." Second, adolescents are among the most frequent consumers of SEM [31–32] and perceive media depictions as real [32]. Furthermore, teenagers are affected by the way they interact (e.g., use and understand) the media and often allowing the media to influence and define their sex, love, and relationships [33]. Finally, in many developed countries, access to SEM is strongly and legally regulated, which makes it more attractive to youths because of the "forbidden fruit" effect [34].

The above reasoning suggests that adolescents and young adults are consumers of SEM and are susceptible to SEM. However, if the content of SEM is not "harmful," exposure to SEM may not lead to negative consequences. For example, some have argued that SEM provides sexual education [35–36] and increases gender egalitarian attitudes [37]. Unfortunately, research has shown that the content of SEM overly depicts gratification of sexual behaviors and pays little or no attention to negative consequences [38], degrades women and "skew[s] away from intimacy and tenderness" (p.984) [39], and delivers an overly permissive sexual script [24]. Consequently, most previous studies have demonstrated that exposure to SEM during adolescence is related to early sexual debut [40–41], inconsistent condom use/unsafe sex [20, 25], and multiple sexual partners [42–43]. However, the "supposed" negative impact of SEM exposure and risky sexual behavior was not unequivocally found in other studies [44–48]. For example, a recent study found that SEM exposure was not related to either early sexual debut [48] or multiple sexual partners (i.e., greater than two sexual partners) [44].

Notwithstanding sampling variations and measurement differences, mixed results may also be due to omitted variable bias and/or self-selection bias (i.e., sexually active youths are more likely to view sexual content in the media) which prevent us from knowing the substantive relationship between SEM exposure and later risky sexual behavior [49–51]. As Tolman and McClelland argued [51], "the effects of seeing sexual media are plagued by a 'chicken or egg' challenge"; that is, whether youths who are sexually open are more likely to use SEM or adolescents become sexually active because of SEM exposure. Use of randomized controlled trials (RCTs), the "gold standard," might also be inapplicable because of legal (e.g., presenting sexual content to minors) and ethical (e.g., assigning individuals to conditions that may compromise health) issues. Another common method to account for a self-selection bias is through a matching process. Three previous studies employed propensity score matching and all revealed that SEM exposure was not related to sexual initiation [46–47, 49]. However, propensity scores may be able to "eliminate" observable differences (i.e., matching on observable characteristics) but is limited in accounting for unobservable heterogeneity (i.e., unobservable differences). One means of rectifying these limitations is to use panel data to estimate the relationship, while including an instrumental variable (IV), as a means of approximating an RCT. Consequently, when properly used [52], the IV method provides a means of identifying a treatment effect from observational data (i.e., the substantive relationship).

Beside methodological limitations, whether exposure to various modalities of SEM will lead to a higher probability of risky sexual behavior has not received much research attention. Many previous studies have focused on only some types of sexually explicit material (e.g., X-rated movies or SEM websites) [44–48] and certain effects (e.g., early sexual debut or multiple sexual partners). To our knowledge, only one previous study examined the effect of exposure to several types of sexually explicit material and found that exposure to various SEM modalities was positively associated with the likelihood of casual sex and early sexual debut [31]. Given the mixed results of the relationship between SEM exposure and later risky sexual behavior and only one study that provided a more nuanced examination of the effects of multi-modal SEM exposure on risky sexual behavior, further study that accounts for methodological limitations and at the same time considers multi-modality SEM exposure and different risky sexual behaviors is warranted.

Finally, most previous studies have relied on Western samples (e.g., United States, United Kingdom, and European countries). SEM exposure and its relationship with risky sexual behaviors in somewhat more conservative societies (e.g., Asian countries) has been understudied. From the available current literature, it would appear that both SEM exposure and risky sexual behavior are quite different in Asian cultures than in Western countries. For example, studies from several East Asian countries showed that the SEM exposure rate among adolescents and young adults was around 50%: 4.5–57% in China [53], 40–43% in Taiwan [54] and Korea [55], and 9–53% in Hong Kong [56]; in contrast, studies from Western societies, including the United States [57], England [58], Sweden [59], Germany [60], and Australia [61] usually report exposure rates of 80% or higher. Similarly, using early onset of sexual behavior as an example, the proportion of adolescents who have sexual intercourse at young age (i.e., $\leqq 16$ or $\leqq 14$) is usually higher in Western society than in Asia [62–64]. Given these substantial differences, replicating the results from Western to a more conservative Eastern setting is important. Velezmoro and colleagues [65] have argued that studying sexual expression in different cultural settings sheds much light on the similarities and differences of the same phenomenon across cultures. Furthermore, some Asian countries suffer from increasing prevalence of STIs, such as an increased rate of HIV infection among young population in China [53, 66] and South Korea [67] and both HIV and other STIs (e.g., gonorrhea) are at their highest rates among adolescents and young adults (11–29) in Taiwan [8]. Although a few studies have been conducted and yielded similar results, these studies also suffered from the aforementioned limitations [68, 53–54].

The present study

This study used IV estimation and a prospective cohort design to explore the relationship between SEM exposure in early adolescence and risky sexual behavior in emerging adulthood. We also examined the effects of multiple modalities of SEM (e.g., Internet and film) on risky sexual behavior. All the analyses were conducted using a sample from Taiwan, a more conservative society; hence, cross-cultural similarities and differences might be discovered [65]. We hypothesized that SEM exposure is related to later risky sexual behavior, and that the relationship would be stronger when adolescents used more SEM modalities. Finally, given that boys and girls experience physical development differently [69] and are socialized differently regarding sexual behavior [70], in addition to the main effect, we also stratified by gender to examine any differences in the relationship between SEM exposure and sexual behavior among males and females.

Materials and methods

Participants and study design

Data were drawn from the Taiwan Youth Project (TYP), a prospective cohort study of junior high school students from two cities (New Taipei City and Taipei) and one county (Yi-Lan County) in Northern Taiwan in that was initiated in 2000. In each selected school, two classes were randomly selected for each grade (7th grade (J1) and 9th grade (J3)), and all students in each selected class were recruited. Those who participated at baseline were followed annually until 2009 (wave 9), although some waves were not exactly one year apart. In 2011, the research team conducted wave 10, and have since completed two further follow-ups three years apart (wave 11 in 2014 and wave 12 in 2017). This study examined the J1 cohort (7th grade) data from wave 1 (baseline; mean age = 13.3 (SD = .49)) to wave 10 (mean age = 24.3 (SD = .47)).

This study examined J1 cohort (7th grade) data from wave 1 (baseline; mean age = 13.3 (SD = .49)) to wave 10 (mean age = 24.3 (SD = .47)). Approximately half the sample was male

(51%). The sample size for examining early sexual debut and unsafe sex was 2,054, while that for multiple sexual partners was 1,477. The difference in sample size is due to different non-response rates. This drop of sample size occurred because the between-wave time lag was longer (i.e., two and half years between wave 9 and 10) compared to previous waves. The baseline data (wave 1) and wave 2 data (i.e., SEM exposure) were based on adolescents' in-class self-report; in contrast, a parallel parental survey was used for parental education and family income, which conducted through in-home interview. For later waves of our subjects (wave 8, 9, and 10), in-home interview were conducted to collect all the data. At baseline (wave 1), all adolescents who agreed to participate gave oral consent. For these participated adolescents, one of their biological parents or legal guardians provided written consent. In addition, they were also invited to participate this research, and about 97% of them participated. The current study was approved by the internal review board at the National Yang Ming University (YM108005E) where the first author served as a faculty member.

Measures

Sexually explicit media exposure (wave 2)

This variable was measured at wave 2 (mean age = 14.3) using one question: "Have you ever seen any of the following adult-only or restricted (R-rated) media?" They were given a list of six media modalities: websites, magazines, comic books, novels, films, and other. While "adult-only" and "R-rated media" are not necessarily sexual in nature in many societies, the wording of the question in Mandarin (*Xian Zni Ji*) would be understood in Taiwanese society as referring to sexually explicit content (e.g., sexual intercourse and nudity). Hence, this item captured the intended SEM content. The items related to SEM exposure and sexual behavior were sensitive; hence, participants might be unwilling to report. To avoid this, all the TYP survey was self-report and was completed in the students' classroom where only participating students and research team assistants were present. The research assistants explained to the students that no one other than the researchers would see the content of their survey and that all surveys were anonymous. Two variables were created to capture SEM exposure: multi-modality exposure and ever-exposure. For the former, we counted the number of modalities to which students were exposed, so the score ranged from 0 (no exposure) to 6 (used all six modalities). For the latter, participants were divided into SEM exposure (1) and non-exposure (0).

Risky sexual behavior (wave 8-wave 10)

This variable included three behaviors: *early sexual debut*, *unsafe sex*, and *multiple sexual partners*. *Early sexual debut* was measured at wave 8 (mean age = 20.3). Each participant was asked to report his or her age of first sexual intercourse. Consensus on what age is considered to represent an early debut has not been reached in the literature, with various studies using different ages as the cut-off, such as 14 years old or younger [71], 16 years old or younger [72–73], or even 17/18 years old or younger [74]. Depending on the age used, the percentage of early initiators range from 17% [72] to 44% [73]. In the present study, 17 years of age or younger was used as the cut-off, which results in a percentage of about 11.9% (*n* = 245) of the sample being classified as early initiators. This cut-off is meaningful in the Taiwanese context for two reasons. First, age 18 is legally considered as adult. Furthermore, the summer of age 18 is the peak season during which adolescents lost their virginity because they graduated from high school and were about to enter college, which is also found in South Korea where educational system and culture is similar [75]. Second, the percentage of this cut-off is close to representative samples from high school students (10th-12th grade), which showed that about 13% of high school students had had sexual intercourse already [76].

Unsafe sex was evaluated at wave 8 with a question on condom use during sexual intercourse (i.e., "Do you use condoms when you engage in sexual intercourse?"). The response categories included "no experience," "always use a condom," "sometimes use a condom," and "do not use a condom most of the time." Participants who selected the last two responses were considered to practice unsafe sex. Although this particular measure might be different from commonly used measures (e.g., condom use for recent sexual intercourse), it captured the respondents' usual practice. Hence, it provided data regarding common condom use rather than just recent use or use in a particular situation. Hence, it captured the "true" meaning of unsafe sexual behavior. Based on this measure, the percentage of unsafe sexual practice is 18%.

Finally, at wave 10 (mean age = 24.3), participants were asked their lifetime number of sexual partners. This was used to gauge *multiple sexual partners*. The numbers ranged from 0 (no sexual experience) to 25 (mean = 1.76; SD = 2.46). Although the measure of risky sexual behavior may include various sexual behaviors, all of the behaviors assessed commonly increase individual's risk of contracting STIs. As such, this study used early sexual debut, unsafe sex, and multiple sexual partners as three types of risky sexual behavior. One previous study used these three behaviors [1] and others used two of these three as the measure of risky sexual behavior [48]. Furthermore, early sexual debut and multiple sexual partners have been related to a high probability of unsafe sex and contraction of STIs [77–78]. While our measure may not exhaustive, it does include important risky sexual behaviors that have been assessed in previous studies.

Pubertal timing (wave 1)

Pubertal timing was evaluated at wave 1 (mean age = 13.3) via self-report. For girls, four self-reported items from the Pubertal Development Scale (PDS) were employed [79]: pubic hair development, skin change, age of menarche, and growth spurt (α = .40). The response categories ranged from 1 (not yet begun) to 4 (fully developed). Girls were classified into three pubertal timing groups based on cut-offs of one standard deviation (*SD*) from the mean PDS score: (1) early (1 *SD* above the mean), (2) late (1 *SD* below the mean), and (3) on-time. For boys, we also used items from the PDS: change of voice, pubic hair development, beard development, skin change, and growth spurt (α = .68). The responses and grouping scheme were identical to those for girls. This grouping method has been used in previous studies [80–81] and the reliability and validity of the PDS have been confirmed [82]. The PDS has been shown to provide a suitable measure of puberty and to capture the subjective and social aspects of pubertal development [83]. However, while this measure has been validated in previous studies, it may not be able to capture a similar concept when used cross-culturally. Two indirect findings may address this concern. First, literature has shown that early pubertal timing is related to delinquency and depression [84–85], and two studies that used the same dataset as this study have demonstrated this relationship [80, 86]. Second, the distribution of age of menarche from a national representative sample of Taiwanese adolescents was very similar to the present sample (national representative sample: 82.8% before or at 7th grade; current study: 88% before or at 7th grade) [87]. In sum, the PDS provides a reasonable measure of pubertal development in Taiwan. In subsequent analyses, variation in PDS scores was used to create the IV.

Control variables (wave 1 and wave 2)

The present study controlled for several potential confounders: gender [88], paternal education level, maternal education level [89], monthly family income [90], family intactness [91], number of siblings, presence of older siblings [92], parental control [93], family cohesion [94], academic performance [95], self-rated health [96], depressive symptoms [97], romantic

relationship [98], and school fixed effect [99]. Each variable has been found to be related to either adolescent sexuality or SEM and risky sexual behavior. For example, family related variables (e.g., parental control and cohesion) captured a possibility that family and parents often play a central role in influencing adolescents' deviant behaviors (i.e., SEM exposure and risky sexual behavior). Similarly, as mentioned above, problem social control may curtail adolescents' unconventional behaviors, such as SEM use and risky sexual behavior. Furthermore, the social learning perspective may argue that sibling and peer effects play important roles in deviance during adolescence and emerging adulthood [100]; hence, we control for the number of sibling as well. Other factors (e.g., school) may create an environment where adolescents receive various exposures that may later influence their behaviors (e.g., sexual education). All variables were assessed at wave 1 or 2. Adolescent *gender* was coded as male (1) or female (0). Both *paternal* and *maternal education* levels were derived from the parental survey at wave 1 and were scored in three categories: lower than high school, high school, and junior college or above. In all subsequent analyses, two dummy variables were used with "lower than high school" as the reference group. *Monthly family income*, measured at wave 1 from the parental survey, was divided into five groups (based on new Taiwan dollars): less than 30,000, 30,000–50,000, 50,001–100,000, 100,001–150,000, and more than 150,000. Similarly, four dummy variables were used with "less than 30,000" as the reference category. *Family intactness* was a dichotomized variable with non-intactness as the reference group, which was based on wave 2 self-report. All the sibling measures were based on adolescents' self-report at wave 1 and included the number of siblings each participant has and each siblings' birth order. From this information, we created *number of siblings* and *presence of older siblings*. The latter included three groups: only child, yes, and no (reference group). *Parental control* was based on the summation of 5-dichotomized items that asked adolescents whether their parents control five daily activities (e.g., phone usage time and TV time). Higher scores indicated higher parental control. *Family cohesion* was based on the summation of six items that captured mutual family help and emotional attachment (e.g., "when I am down, I can receive comfort from my family"). Each item was based on 4-point Likert scale (i.e., "strongly disagree" to "strongly agree"). Higher scores indicated higher family cohesion. *Academic performance* was assessed with the question, "What is your class rank this semester?" The response categories were 1 (top 5), 2 (6–10), 3 (11–20), and 4 (over 21). *Health status* was based on self-rated health using five response categories. We grouped individuals into three categories: bad/very bad (reference group), fair, and good/very good. *Depressive symptoms* was a summation across a 7-item depressive symptom scale (e.g., "I feel depressed"), which was adopted from the Symptom Checklist-90-Revised (SCL-90-R) [101]. Each item was based on 5-point scale (i.e., no (0) to yes and very serious (4)). Summation across the seven items was used to calculate a total score. Dating experience was based on one item, which asked adolescents whether they have a boy/girlfriend. Finally, unobserved factors in school were controlled for by including *school fixed effect* in the subsequent analyses (descriptive statistics for all variables can be found in Table 1).

Statistical analysis

The linear probability model (LPM) based on the ordinary least squares (OLS) method was used to estimate the longitudinal effects of SEM exposure (ever-exposure and multi-modality exposure) during early adolescence on three risky sexual behaviors. While the convention for our outcomes may be using logit/probit model for dichotomized (i.e., early sexual debut and unsafe sex) and Poisson for count variable (i.e., multiple sexual partners), we employed OLS for several reasons. First, Hellevik [102] indicated that LPM is close to the logit model in most applications but has the advantage that its coefficients are easier to explain. Second, the main

Table 1. Descriptive statistics for all variables.

	Full Sample[1]		Early sex debut/ Unsafe sex		Multiple sexual partner		Mean difference[3] pubertal timing early/on-time vs. late	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Coefficient	Std. Err.
Dependent Variables								
Early sex debut (first sex before age 17)			0.119	0.324			0.035**	(0.016)
Unsafe sex			0.181	0.385			0.039*	(0.021)
Number of sex partner (Min-Max: 0–25)					1.760	2.469	0.441***	(0.141)
Control Variables								
SEM exposure (wave 2)	0.502	0.500	0.504	0.500	0.509	0.500	0.091***	(0.023)
Multi-modality SEM: (Min-Max: 0–6)	1.018	1.367	1.019	1.366	1.007	1.324	0.228***	(0.070)
Comic books	0.324	0.468	0.327	0.469	0.336	0.472	0.060**	(0.026)
Novels	0.177	0.382	0.180	0.384	0.181	0.386	0.073***	(0.018)
Magazines	0.097	0.296	0.094	0.293	0.087	0.281	-0.004	(0.016)
Websites/webpage	0.185	0.389	0.185	0.389	0.177	0.382	0.054**	(0.026)
Films	0.227	0.419	0.226	0.418	0.219	0.414	0.037*	(0.019)
Others	0.007	0.086	0.007	0.085	0.007	0.082	0.009***	(0.002)
Pubertal timing: on-time (wave 1)[2]	0.687	0.464	0.692	0.462	0.693	0.462		
Pubertal timing: early	0.133	0.340	0.129	0.335	0.126	0.332		
Male (wave 1)	0.512	0.500	0.518	0.500	0.529	0.499	-0.197***	(0.035)
Father's education: high school[2]	0.319	0.466	0.316	0.465	0.315	0.465	-0.006	(0.023)
Father's education: junior college/above	0.240	0.427	0.235	0.424	0.238	0.426	-0.002	(0.024)
Mother's education: below high school[2]	0.362	0.481	0.358	0.479	0.365	0.482	-0.014	(0.032)
Mother's education: junior college/ above	0.149	0.356	0.146	0.353	0.146	0.353	-0.005	(0.020)
Monthly income: 30k-50k (NTD)[2]	0.268	0.443	0.274	0.446	0.279	0.449	-0.030	(0.022)
Monthly income: 50-100K	0.440	0.496	0.445	0.497	0.448	0.497	-0.033	(0.023)
Monthly income: 100K-150K	0.110	0.313	0.106	0.308	0.100	0.300	0.020	(0.015)
Monthly income: above 150K	0.035	0.183	0.032	0.176	0.028	0.166	-0.001	(0.012)
Family intactness (wave 2)	0.875	0.330	0.888	0.316	0.889	0.314	0.012	(0.023)
Number of sibling (wave 1)	2.622	0.896	2.628	0.873	2.642	0.856	-0.037	(0.061)
Only child (wave 1)	0.059	0.235	0.051	0.220	0.042	0.201	0.013	(0.013)
Presence of older sibling (wave 1)	0.569	0.495	0.564	0.496	0.564	0.496	-0.024	(0.030)
Parental control (wave 1)	2.630	1.659	2.579	1.642	2.588	1.633	-0.180*	(0.098)
Family cohesion (wave 1)	18.047	3.862	18.136	3.855	18.084	3.907	-0.295*	(0.173)
Class rank in 7th grade: ranked 6–10 (wave 1)[2]	0.182	0.386	0.192	0.394	0.208	0.406	0.015	(0.022)
Class rank in 7th grade: ranked 11–20	0.325	0.469	0.327	0.469	0.331	0.471	0.021	(0.031)
Class rank in 7th grade: ranked over 20	0.343	0.475	0.320	0.467	0.284	0.451	-0.024	(0.031)
Health status: fair (wave 2)[2]	0.299	0.458	0.293	0.455	0.289	0.453	0.015	(0.028)
Health status: good/very good	0.641	0.480	0.646	0.478	0.645	0.479	-0.024	(0.030)
Depressive symptom (wave 2)	3.364	3.671	3.287	3.618	3.350	3.657	0.379	(0.237)
Dating experience (wave 2)	0.129	0.336	0.114	0.318	0.114	0.318	0.046***	(0.014)
Joint test of covariates being zeros:[3]								
F statistics [p-value]							1.50	[0.149]
Observations	2,661		2,054		1,477			

[1] The initial sample size in wave 1 (age 13.3) is 2690 but 29 individuals (1%) had missing value on the listed variables. SEM exposure measures are from wave 2 (age 14.3) with sample size 2, 568. Except for parental educational levels and monthly income, all variables are from either the wave 1 or wave 2 of student' survey as indicated in the parentheses.

[2] The reference groups for these variables are: "late" for *pubertal timing*; "below high school" for both *father's education* and *mother's education*; "below 30K" for *monthly income*; "ranked at 1–5" for *class rank in 7th grade*; "bad/very bad" for *health status*.

[3] The 2,061 samples are used in computing the mean difference in each variable between early/on-time pubertal timing and late pubertal timing as well as the joint test of covariates being zeros. The joint test is conducted from the regression of *pubertal timing being early or on-time* on all control variables and junior high school fixed effects. This F-test examines whether the probability of pubertal timing being early or on-time is related to *class rank in 7th grade*, *health status*, *depressive symptom*, *father's education*, *mother's education*, *monthly income*, *intact family*, and *number of sibling*. Heteroskedasticity-robust standard errors in the parentheses clustered at the junior high school.

*** p<0.01,

** p<0.05,

* p<0.1.

empirical model in the paper is two-stage least squares (2SLS) instrumental variable regressions, which is a linear model. Thus, regression analysis uses linear regression models or linear probability models for the convenience of comparison and intuition to convey the meaning of coefficients. While many covariates were controlled for, the estimated effect might still be biased due to unobserved confounding variables. Thus, to find a consistent, unbiased estimate of the effects of SEM exposure on risky sexual behaviors among adolescents, the 2SLS method with pubertal timing as the IV was used.

Variation in pubertal timing for the same cohort ($pubertal1_i$ and $pubertal2_i$) is used to instrument for SEM exposure ($y_{sem,i}$) in the first stage, with controls of individual characteristics (X_i) and junior high school fixed effects (a_{i0}):

$$y_{sem,i} = a_{0i} + X_i^{'}\beta + \gamma_1(pubertal1)_i + \gamma_2(pubertal2)_i + v_i \tag{1}$$

where $y_{sem,i}$ is the dependent for multi-modality SEM exposure and SEM exposure, respectively; the term v_i is the error term. The relationship between pubertal timing and SEM exposure should be positive. A F joint test is applied for testing the hypothesis that the coefficients on the instruments (i.e., pubertal timing) are all zero. When the corresponding F-statistic exceeds 10, then the instruments are strongly correlated with SEM exposure.

The second-stage equation estimate the effect of SEM exposure in early adolescence on risky sex behavior ($y_{risky\ sexual\ behavior}$) in emerging adulthood:

$$y_{risky\ sexual\ behavior} = a_{0i} + X_i^{'}\beta + \gamma y_{sem,i} + u_i \tag{2}$$

where $y_{risky\ sexual\ behavior}$ is risky sexual behavior for early sex debut, unsafe sex, and number of sex partners, respectively; individual characteristics (X_i) and junior high school fixed effects (a_{i0}) are the same as those in Eq (1) and the endogenous variable in (2) is the SEM exposure ($y_{sem,i}$). We will separately estimate the effects of SEM-viewer and multi-modality SEM exposure on risky sexual behavior (all first stage analyses can be found in S1 Appendix).

Pubertal timing was set as the IV, as it fulfills the two main requirements of valid IVs: relevance and exogeneity [103]. The former requires the IV to be strongly related to the treatment (i.e., SEM exposure). Puberty is characterized by hormone elevation, and studies have shown that SEM exposure is prevalent during adolescence. Thus, individuals experiencing early puberty are more likely to be exposed to SEM than their counterparts, and this has been supported by numerous studies [104–105]. This requirement can also be statistically verified via the F-statistic ($F > 10$) in the first stage of a 2SLS [106]. Exogeneity, on the other hand, requires that the IV be uncorrelated with the error term in the regression equation. First, pubertal development is a biological process that almost all people experience. This development is influenced by genes and the environment, over which individuals have no control [107]. For example, twin studies have shown that approximately 50–80% of the variations in menarche timing are due to genetic factors and the remainder can be attributed to a non-shared environment or measurement error [108–109]. For the latter, as showed in the last column and the bottom of Table 1, the paper examines the possible correlation between pubertal timing and socioeconomic resources and did not find any significant correlation between pubertal timing and some observable socioeconomic resources (e.g., parental level of education and family monthly income). In addition, numerous environmental factors (e.g., school and family) were controlled for in the analyses, which might alleviate the concern of omitted variable bias. Accordingly, the IVs should be more likely to be uncorrelated with any of the unobserved factors that determined risky sexual behaviors. Furthermore, the estimated model included two IVs (two dummy variables). The over-identifying test (J-test) or the Sargan-Hansen test [110] can provide a statistical assessment of whether the estimated treatment effects are consistent in the 2SLS estimation.

While a valid IV design can provide causal estimates, attrition or missing data can still bias these estimates. This study used several methods to check for possible biases. First, our analytic sample was based on those who had information on SEM consumption in wave 2; the rate of missing data for all of the other explanatory variables including the instrumental variable (pubertal timing) was very low (See Table 1). Consequently, missing data on the right-hand side variable in the consequent analytic models may not be a serious issue. Second, the proportion of missing data on risky sexual behavior was not as low: 20% (514/2,568) for both early sexual debut and unsafe sex and 42% (1,091/2,568) for multiple sexual partners. Most of the missing data is due to attrition. For those who did not answer the first two risky sexual behavior questions (i.e., early sexual debut and inconsistent condom use), we imputed each item by checking their report on the same item at wave 9 or wave 10. However, for multiple sexual partners, we dropped those who did not provide a response. Third, we compared the distribution of the imputed sample to the original sample on pubertal timing, SEM exposure, and all of the control variables (see Table 1). As can be seen, the differences of the mean and *SD* between our various imputed samples and the original sample on all of the used variables were only minor. Finally, a Heckman selection model was used to see if attrition was related to risky sexual behavior. In this model, we used four variables as exclusion restrictions: housing type (e.g., live in a stand-alone house or an apartment), loving the current living area, neighborhood safety (e.g., "Do you think your neighborhood is safe?"), and number of years living at the current address. The results can be found in Table 2. From the bottom part of Table 2, one can find that the Wald tests indicated that the correlation between sample attrition and risky sexual behavior is not significant in all models (i.e., the two equations are independent of each other). In other words, attrition is not related to the decisions of engaging in risky sexual behaviors. These extra tests provided confidence that missing data on the outcome variables may be random. Consequently, the resulting estimates were unbiased but at the expense of the loss of precision and power because the standard errors were always larger than the estimates based on the full data. All statistical tests were based on 2-sided hypothesis tests with heteroskedasticity-robust standard errors adjusted for clustering at the junior high school level and were performed using Stata software (Stata 13.1; Stata Corp, College Station, TX).

Results

Descriptive statistics

As indicated in Table 1, about half the adolescents (50%) were exposed to SEM in early adolescence, at an average of one modality (M = 1.02; SD = 1.37). The most common modality was comic books (32.7%) and the least common was magazines (9.4%). Overall, however, the prevalence of risky sexual behavior was low: early sexual debut, 11.9%; unsafe sex, 18.1%; average lifetime sexual partners was about 2. Gender differences were found in two out of three risky sexual behaviors (unsafe sex and number of sex partners), with males being more likely to be involved in these behaviors. In addition, a significant *t*-test result (*t* = -3.87; *p* < .01) indicated that males, on average, had more sexual partners (M = 1.99) than did females (M = 1.51). As can be seen, the most common SEM modality was comic books (32.7%), followed by films (22.7%). Surprisingly, only about 18.5% of adolescents used the Internet to view SEM. Additional analyses showed that more boys used each type of SEM more than girls did, with one exception: girls (22.5%) were more exposed to novels than were boys (13.7%). Furthermore, the *t*-test result (*t* = -7.2; *p* < .01) indicated that male adolescents, on average, used more types of SEM than female adolescents did.

Table 2. Selection models for relationship between non-missing and risky sex outcomes[1].

	No missing	Early sex debut	No missing	Unsafe sex	No missing	Multiple sexual partner
Male (wave1)	0.035	0.052	0.037	0.085	0.152***	0.161**
	(0.082)	(0.073)	(0.083)	(0.068)	(0.055)	(0.063)
Multi-modality SEM (wave2)	0.034	0.151***	0.036	0.137***	0.012	0.174**
	(0.023)	(0.026)	(0.023)	(0.030)	(0.020)	(0.083)
Pubertal timing: on-time/ early (wave1)	0.015	0.172	0.010	0.128	-0.014	0.044
	(0.082)	(0.102)	(0.082)	(0.092)	(0.082)	(0.086)
Father's education: high school[2]	-0.037	0.097	-0.036	-0.001	-0.007	0.120
	(0.072)	(0.107)	(0.070)	(0.088)	(0.069)	(0.108)
Father's education: junior college/above	-0.089	0.225	-0.075	-0.031	-0.035	0.015
	(0.073)	(0.143)	(0.072)	(0.117)	(0.088)	(0.108)
Mom's education: high school[2]	0.026	-0.063	0.033	-0.065	0.091	0.035
	(0.077)	(0.088)	(0.078)	(0.099)	(0.075)	(0.091)
Mom's education: junior college/above	0.028	0.002	0.028	0.041	0.052	0.048
	(0.114)	(0.150)	(0.113)	(0.122)	(0.112)	(0.144)
Monthly income: 30K-50K (NTD)[2]	0.090	0.003	0.100	-0.031	-0.001	0.073
	(0.082)	(0.139)	(0.081)	(0.087)	(0.083)	(0.106)
Monthly income: 50K-100K	0.197	0.071	0.195	0.057	0.021	0.114
	(0.112)	(0.139)	(0.111)	(0.099)	(0.092)	(0.124)
Monthly income: 100K-150K	0.185	-0.070	0.175	0.009	-0.146	-0.077
	(0.136)	(0.192)	(0.136)	(0.135)	(0.109)	(0.166)
Monthly income: above 150K	0.034	0.169	0.024	0.200	-0.300	-0.032
	(0.247)	(0.235)	(0.241)	(0.211)	(0.176)	(0.215)
Intact Family (wave 2)	0.230***	-0.231**	0.235***	-0.216**	0.104	-0.210
	(0.087)	(0.104)	(0.085)	(0.098)	(0.085)	(0.238)
Number of sibling (wave1)	-0.026	0.015	-0.023	-0.055	0.014	-0.011
	(0.048)	(0.050)	(0.047)	(0.045)	(0.032)	(0.039)
Only child (wave1)	-0.293	-0.200	-0.285	-0.170	-0.396***	-0.206
	(0.154)	(0.209)	(0.157)	(0.207)	(0.127)	(0.222)
Presence of older sibling (wave1)	-0.103	-0.071	-0.106	0.049	-0.072	0.040
	(0.073)	(0.086)	(0.073)	(0.068)	(0.057)	(0.098)
Parental control (wave1)	-0.040	-0.002	-0.041**	-0.000	-0.012	0.013
	(0.022)	(0.021)	(0.021)	(0.018)	(0.016)	(0.030)
Family cohesion (wave 1)	0.001	-0.023**	0.001	-0.027***	-0.010	-0.012
	(0.008)	(0.010)	(0.008)	(0.009)	(0.007)	(0.008)
Class rank in 7th grade: 6–10 (wave1)[2]	-0.130	0.283**	-0.124	0.092	-0.098	0.030
	(0.097)	(0.120)	(0.101)	(0.116)	(0.090)	(0.099)
Class rank in 7th grade: 11–20	-0.259***	0.237	-0.257**	0.124	-0.324***	0.105
	(0.099)	(0.128)	(0.101)	(0.108)	(0.087)	(0.229)
Class rank in 7th grade: over 20	-0.422***	0.457***	-0.421***	0.275**	-0.621***	0.009
	(0.108)	(0.147)	(0.106)	(0.124)	(0.089)	(0.363)
Health status: fair (wave 2)[2]	-0.266**	0.074	-0.272**	0.251	-0.283**	0.067
	(0.120)	(0.214)	(0.121)	(0.212)	(0.126)	(0.236)
Health status: good/very good	-0.206	0.198	-0.208	0.420**	-0.223	0.160
	(0.135)	(0.223)	(0.136)	(0.192)	(0.116)	(0.214)
Depressive symptom (wave 2)	-0.016	0.007	-0.016**	0.006	-0.005	-0.003
	(0.008)	(0.014)	(0.008)	(0.010)	(0.007)	(0.010)

(Continued)

Table 2. (Continued)

	No missing	Early sex debut	No missing	Unsafe sex	No missing	Multiple sexual partner
Dating experience (wave 2)	-0.367***	0.271**	-0.365***	0.412***	-0.193**	0.440
	(0.088)	(0.138)	(0.089)	(0.108)	(0.091)	(0.389)
Housing types: house[2]	0.102		0.108		0.054	
	(0.078)		(0.078)		(0.098)	
Housing types: other types	-0.110		-0.085		-0.109	
	(0.157)		(0.156)		(0.147)	
Love the current living area	-0.050		-0.058		-0.015	
	(0.089)		(0.087)		(0.122)	
Years of living	0.027***		0.026***		0.015***	
	(0.005)		(0.005)		(0.006)	
Years of living, squared	-0.000***		-0.000***		-0.000**	
	(0.000)		(0.000)		(0.000)	
Public security around home	0.065**		0.069**		-0.020	
	(0.031)		(0.033)		(0.029)	
Wald test for two independent equations:[1]						
Chi-squared statistic (p-value)	1.13	(0.287)	2.29	(0.130)	0.47	(0.491)
Observations	2,568	2,054	2,568	2,054	2,568	1477

[1] The sample size for non-missing observations in *pubertal timing* and *SEM exposure* is 2, 568. The analytic samples for *early sex debut*, *unsafe sex* and *number of sex partner* models are 2054, 2054, and 1477. The *no missing* equals to 1 if the dependent variable is observed and 0 otherwise. Wald test with null hypothesis that the two equations are independent is applied. Except for parental educational levels, monthly income, housing types, years of living, and public security around home, all variables are from the waves 1 or 2 of student' survey indicated in the parentheses.

[2] The reference groups for these variables are: "below high school" for both *father's education* and *mother's education*; "below 30K" for *monthly income*;ranked at 1–5" for *class rank in 7th grade*; "bad/very bad" for *health status*; "Apartment" for *housing types*. All the models are estimated by using *housing types*, *years of living*, *squared years of living*, and *public security around home* as the exclusion restrictions. Heteroskedasticity-robust standard errors in the parentheses clustered at the junior high school.

*** p<0.01,

** p<0.05.

Sexually explicit media exposure and risky sexual behavior

A consistent finding (see Fig 1A and 1B) was that SEM exposure in early adolescence was significantly related to risky sexual behaviors in late adolescence (detail in S2 Appendix). Specifically, in Fig 1A and 1B, the results of the 2SLS estimation revealed that relative to their counterparts, adolescents exposed to SEM in early adolescence were 31.7% and 27.4% more likely to engage in sexual behavior before age 17 and to engage in unsafe sex, respectively. Moreover, these youths had on average three or more sexual partners by age 24. The estimated effects from the 2SLS models were 2.8 to 5.7 times larger than were those of the OLS estimations.

As shown in Table 3, the effects of multi-modality SEM exposure on risky sexual behavior were also strong. The adolescents were 12.3% and 10.8% more likely to have made an early sexual debut and be involved in unsafe sex, respectively, when they viewed one or more SEM modalities during early adolescence compared to those who did not view any SEM. Of greater concern is that every modality during early adolescence led to, on average, one more sexual partner during late adolescence. The effect of multi-modality of SEM can be further understood by Fig 2 where we demonstrate the different probabilities of being involved in early sexual behavior and unsafe sex and the multiple sexual partners (to the nearest integer) at 1
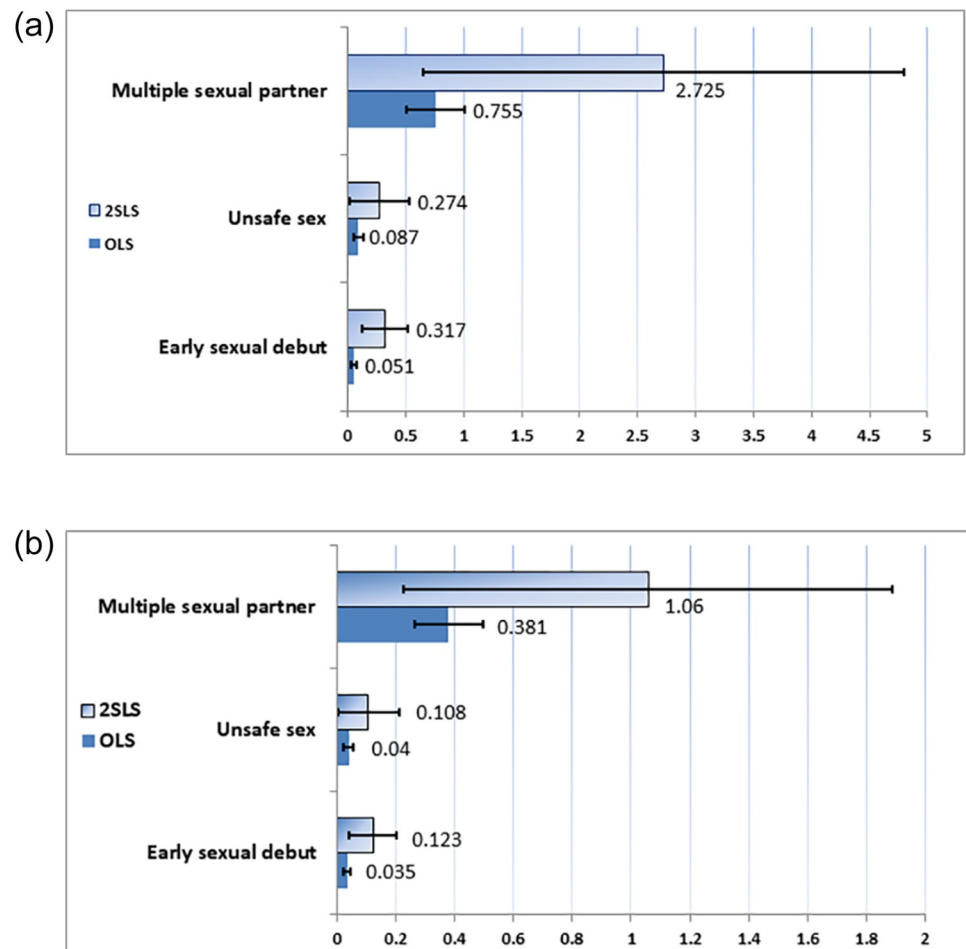
Fig 1. Main effects from OLS and 2SLS results. (a) The increased likelihood of early sexual debut and unsafe sex, and the increased number of sexual partner from SEM exposure for both OLS and 2SLS results (b) The increased likelihood of early sexual debut and unsafe sex, and the increased number of sexual partner for additional exposure to SEM for both OLS and 2SLS results.

(mean), 2 (1 *SD*),4 (2 *SD*), and 6 (the highest) modalities. From the graphic, the trend clearly demonstrates that more exposure was related to a higher probability of risky sexual behavior and a greater number of sexual partners. The difference was pronounced between the mean (1 modality) and the extreme (6 modalities). The 2SLS estimations were 2.3 to 3.4 times larger than were those of the OLS. The results from above were consistent with those of previous studies that found SEM exposure is related to various risky sexual behaviors [20, 41–43, 56–57].

Although SEM exposure was substantively related to later risky sexual behaviors, the estimated effects could be limited to a local average treatment effect (LATE) rather than an average treatment effect (ATE) [111], given that the estimated treatment effects would apply only to compliers (i.e., early maturers who also consumed SEM),and not to all participants, using the current statistical method. To address this issue, the models were estimated by enforcing a functional form so that the treatment effect might be applied to all participants (e.g., a bivariate Probit model for the ever-exposure variable with dichotomized outcomes). As shown in Table 4, the results indicated that all effects of SEM exposure on risky sexual behaviors remained significant, although the magnitudes were slightly reduced.

Table 3. Effects of multi-modality SEM exposure on risky sexual outcomes.

Mean of dependent variable	OLS Results			2SLS Results[1]		
	Early sex debut	Unsafe sex	Multiple sexual partner	Early sex debut	Unsafe sex	Multiple sexual partner
	0.119	**0.181**	**1.76**	**0.119**	**0.181**	**1.76**
	(1)	(2)	(3)	(4)	(5)	(6)
Multi-modality SEM (wave 2)	0.035***	0.040***	0.381***	0.123***	0.108**	1.060**
	(0.006)	(0.009)	(0.058)	(0.041)	(0.054)	(0.425)
Male (wave 1)	0.002	0.013	0.261**	-0.039	-0.019	-0.020
	(0.013)	(0.016)	(0.109)	(0.025)	(0.022)	(0.208)
Father's education: high school[2]	0.016	-0.001	0.161	0.003	-0.011	0.017
	(0.021)	(0.022)	(0.147)	(0.022)	(0.026)	(0.206)
Father's education: junior college/above	0.044	-0.004	0.039	0.040	-0.007	-0.003
	(0.028)	(0.029)	(0.221)	(0.027)	(0.029)	(0.214)
Mom's education: high school[2]	-0.011	-0.013	0.101	-0.009	-0.011	0.102
	(0.018)	(0.027)	(0.159)	(0.019)	(0.027)	(0.160)
Mom's education: junior college/above	0.002	0.015	0.060	0.007	0.020	0.094
	(0.030)	(0.029)	(0.281)	(0.032)	(0.028)	(0.275)
Monthly income: 30K-50K (NTD)[2]	-0.004	-0.014	-0.102	-0.007	-0.016	-0.194
	(0.027)	(0.023)	(0.180)	(0.027)	(0.023)	(0.187)
Monthly income: 50K-100K	0.006	0.001	0.069	-0.000	-0.004	-0.028
	(0.027)	(0.026)	(0.209)	(0.027)	(0.026)	(0.201)
Monthly income: 100K-150K	-0.020	-0.008	0.235	-0.035	-0.019	0.117
	(0.034)	(0.032)	(0.331)	(0.037)	(0.035)	(0.329)
Monthly income: above 150K	0.030	0.042	0.571	-0.020	0.004	0.234
	(0.052)	(0.060)	(0.509)	(0.064)	(0.075)	(0.599)
Family intactness (wave 2)	-0.061**	-0.070**	-0.488	-0.039	-0.053	-0.369
	(0.026)	(0.031)	(0.249)	(0.026)	(0.030)	(0.268)
Number of sibling (wave 1)	0.004	-0.012	-0.166**	0.003	-0.013	-0.147
	(0.009)	(0.011)	(0.069)	(0.009)	(0.011)	(0.080)
Only child (wave 1)	-0.026	-0.027	-0.399	-0.016	-0.019	-0.419
	(0.036)	(0.050)	(0.345)	(0.036)	(0.046)	(0.299)
Presence of older sibling (wave 1)	-0.009	0.015	-0.149	-0.014	0.011	-0.183
	(0.016)	(0.016)	(0.137)	(0.018)	(0.016)	(0.136)
Parental control (wave1)	0.001	0.002	0.071	-0.000	0.001	0.058
	(0.004)	(0.005)	(0.040)	(0.004)	(0.005)	(0.042)
Family cohesion (wave 1)	-0.005**	-0.007***	-0.045**	-0.001	-0.004	-0.022
	(0.002)	(0.002)	(0.018)	(0.003)	(0.003)	(0.024)
Class rank in 7th grade: 6–10 (wave 1)[2]	0.047**	0.026	0.351**	0.043**	0.022	0.300
	(0.017)	(0.026)	(0.170)	(0.019)	(0.026)	(0.191)
Class rank in 7th grade: 11–20	0.041**	0.036	0.462***	0.042**	0.036	0.443**
	(0.019)	(0.024)	(0.156)	(0.019)	(0.025)	(0.174)
Class rank in 7th grade: over 20	0.094***	0.087***	0.631***	0.087***	0.081***	0.609***
	(0.025)	(0.028)	(0.164)	(0.027)	(0.028)	(0.172)
Health status: fair (wave 2)[2]	0.022	0.066	0.417	0.018	0.063	0.476
	(0.036)	(0.039)	(0.241)	(0.034)	(0.039)	(0.262)
Health status: good/very good	0.044	0.106***	0.626**	0.039	0.102***	0.651**
	(0.037)	(0.035)	(0.267)	(0.037)	(0.034)	(0.288)
Depressive symptom (wave 2)	0.002	0.002	0.020	-0.002	-0.001	-0.001

(*Continued*)

Table 3. (*Continued*)

Mean of dependent variable	OLS Results			2SLS Results[1]		
	Early sex debut	Unsafe sex	Multiple sexual partner	Early sex debut	Unsafe sex	Multiple sexual partner
	0.119	**0.181**	**1.76**	**0.119**	**0.181**	**1.76**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	(0.003)	(0.002)	(0.019)	(0.003)	(0.003)	(0.025)
Dating experience (wave 2)	0.092***	0.159***	1.287***	0.053	0.129***	1.075***
	(0.029)	(0.031)	(0.299)	(0.035)	(0.035)	(0.342)
School fixed effects	yes	yes	yes	yes	yes	Yes
First-stage F-statistic[3]				12.93	12.93	9.82
Overidentifying restrictions				0.012	0.285	1.772
J-statistic (p-value)				(0.914)	(0.594)	(0.1832)
Observations	2,054	2,054	1,477	2,054	2,054	1,477
R-squared	0.076	0.089	0.149			

[1] The instrument variables (IVs) in two-stage least squares model (2SLS) are pubertal timing that included two dummy variables for students' pubertal timing being on-time and being early, respectively. The multi-modality SEM exposure is the multiple type of SEM exposure (ranged from 0 to 6).

[2] The reference groups for these variables are: "below high school" for both *father's education* and *mother's education*; "below 30K" for *monthly income*; "ranked at 1–5" for *class rank in 7th grade*; "bad/very bad" for *health status*. Heteroskedasticity-robust standard errors in the parentheses clustered at the junior high school.

*** p<0.01,

** p<0.05,

* p<0.1.

[3] The first-stage F-statistic is the F-statistic testing the hypothesis that the coefficients on the IVs (i.e., *pubertal timing*) equal zero in first stage of 2SLS. Overidentifying test with null hypothesis that the two instruments are consistent with each other is applied.

After confirming the main effect, this study further analyzed the effect by stratifying by gender. While the results remained the same in direction, the magnitude was lower for both gender groups. For boys, the results remained similar; that is, early exposure to SEM and the more modalities to which adolescent boys were exposed, the more likely they were to have first sexual intercourse early and more sexual partners. In contrast, the effects for females all decreased to nonsignificant levels except for early sexual debut. In other words, early exposure to SEM
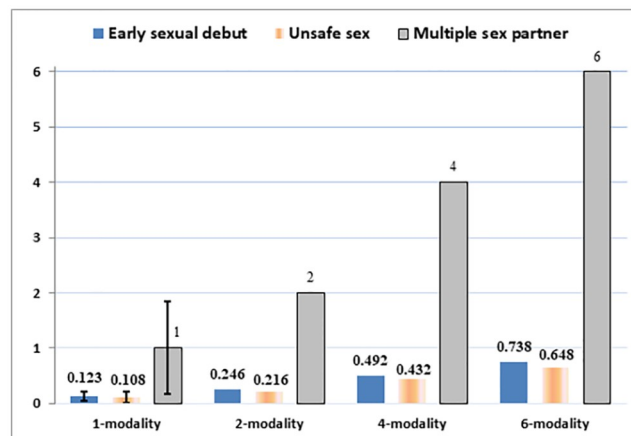

Fig 2. The effects of multi-modality exposure on the probability of risky sexual behavior and sexual partners.

Table 4. Nonlinear structure estimations for effects of SEM on risky sexual outcomes[1].

Mean of dependent variable	SEM exposure on risky sex outcomes			Multi-modality SEM on risky sex outcomes		
	Early sex debut	Unsafe sex	Multiple sexual partner	Early sex debut	Unsafe sex	Multiple sexual partner
	0.119	**0.181**	**1.76**	**0.119**	**0.181**	**1.76**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
2SLS estimates:[2]						
SEM exposure	0.317***	0.274**	2.725**			
	(0.100)	(0.131)	(1.059)			
Multi-modality SEM				0.123***	0.108**	1.060**
				(0.041)	(0.054)	(0.425)
Nonlinear structure estimates:[2]						
SEM exposure	0.318***	0.320***	2.447*			
	(0.086)	(0.074)	(1.267)			
Multi-modality SEM				0.109***	0.098**	0.950*
				(0.030)	(0.040)	(0.513)
Observations	2,054	2,054	1,477	2,054	2,054	1,477

[1] Nonlinear structure estimations for (1) and (2), and for (4) and (5) are probit model with an endogenous binary explanatory variable, *SEM exposure*, and a continuous endogenous explanatory variable, *multi-modality SEM exposure*, respectively. The models (3) and (5) are poisson models with an endogenous explanatory variable for *SEM exposure* and *multi-modality SEM*, respectively. All the models are estimated by using two dummies for pubertal timing (i.e., the instrumental variables) as the exclusion restrictions.

[2] The 2SLS estimates are reproduced for the ease of comparison. The control variables are the same as in 2SLS estimations. Heteroskedasticity-robust standard errors in the parentheses clustered at the junior high school.

*** p<0.01,

** p<0.05,

* p<0.1.

and exposure to more modalities of SEM increased the probability of early sexual intercourse for female adolescents in northern Taiwan. However, one must always keep in mind that all the effects were still in the right direction (i.e., positive effects). Given the reduced sample size, the decrease in magnitude was expected (See S3 Appendix).

Discussion

Many studies have documented that early exposure to SEM may have various negative impacts on the development of risky sexual behavior. Risky sexual behavior has been linked to both physical (e.g., unwanted pregnancy and STIs) and mental (e.g., depression) problems. Furthermore, sexuality-related issues including sexual behavior and SEM exposure may vary across cultures; hence, understanding such relationships in more conservative cultures may provide further insights into this relationship. In addition, given the rise of STIs and teen pregnancy in many Asian countries [53, 66–67] and the call of WHO regarding global adolescent reproductive health [112], understanding the relationship could shed light on preventive strategies. These important considerations along with other limitations of previous studies (e.g., limited measurements of SEM and risky sexual behaviors and methodological limitations), indicated that further investigation of SEM exposure and risky sexual behavior was warranted. The purpose of this study was to build a stronger case for the relationship between SEM exposure and risky sexual behaviors, and at the same time to examine the effect of multi-modality of SEM exposure on three major risky sexual behaviors. Furthermore, this study also examined this relationship in a non-western society.

The results of this study were based on an IV estimation model which identified a causal like effect of SEM exposure on risky sexual behavior (at least for compliers). That is, early maturers who were exposed to SEM were also more likely to engage in risky sexual behavior. Our analyses consistently showed that early SEM exposure (8th grade) is related to risky sexual behaviors in emerging adulthood including early sexual debut, unsafe sex, and multiple lifetime sexual partners. Although the unadjusted model (e.g., regular regression model) and the 2SLS regression both showed significant effects of early SEM exposure on later risky sexual behaviors, the magnitudes of all the estimated coefficients were stronger in the 2SLS models. Hence, the findings of this study not only echoed those of previous studies but also revealed that this relationship is substantive. These results could be understood from two theoretical perspectives. First, social learning theory [113] argues that behavior is learned via direct experience, vicarious experience from observing others (i.e., modeling), and complex cognitive operations (i.e., storing and processing information). Adolescents therefore "observe" behavior in SEM and learn how to perform it. They can also store and process information learned from the SEM (e.g., definitions or consequences of a behavior), thereby increasing or decreasing their likelihood of learning and applying related behavior. Similarly, Wright's acquisition, activation, and application (AAA) model [114] explains that adolescents learn sexual scripts via this triple-A process: namely, they observe and acquire scripts from media, and from then on exposure to similar environmental cues will accentuate the learned scripts ("activation"). When the consequences of the scripted behavior are framed by media as more positive than negative, individuals are more likely to apply the script.

Besides general exposure (e.g., viewer vs. not), we further considered multi-modality of SEM use because Morgan [31] argued that such measure of SEM use is important. Our results showed that multi-modality of SEM use during early adolescence is also substantively related to risky sexual behaviors. In other words, the more modalities of SEM to which one is exposed, the higher probability of engaging in risky sexual behavior in emerging adulthood. The results are also consistent with both social learning theory [113] and the AAA [114] model because more exposure would accentuate the learned scripts and the favorable portrayal of similar behavior in the SEM. While in general dosage-effect is applied to the effect of frequency or intensity of exposure on behavior, some previous publications extend this relationship to accumulation negative experience of different kinds [115–116]. Specifically, Felitti [115] et al argued that their results was a dosage-effect because individuals who experience more different kinds of childhood adversities have lower level of health (e.g., low mental health).

Finally, provided that the functional forms assumed in the further analyses were correct, our results were very close to ATE, which in the present case is the difference in the mean of risky sexual behavior between treated (SEM exposure) and untreated (non-exposure) individuals within the entire population, not just an average treatment effect for a subpopulation (i.e., compliers). This gives us the confidence that early exposure to SEM may be detrimental to an individual's reproductive health and such effects last into emerging adulthood.

Although our main effect was significant and strong, the effects were not omnibus when stratified by gender. While most effects were similar in terms of direction and magnitude, only early sexual debut and multiple sexual partners were significant for boys and early sexual debut for girls. These insignificant results could be due to a lack of power. The dramatic difference for girls might also be related to other important factors. For example, in a patriarchal society (e.g., China, Taiwan, and the U.S.), the gender double standard is very deep-rooted. Hence, while exposure to SEM might trigger early sexual intercourse three to four years later, the stigma for sexual promiscuity (i.e., multiple sexual partners) and lack of power to negotiate protection use may curtail the effects of SEM.

In sum, several strengths highlight our findings. First, our measures of SEM exposure and risky sexual behavior are broader than those used in many previous studies, which enabled

this study to examine the relationship between multi-modality of SEM exposure and various risky sexual behaviors. This strength revealed an interesting dose-response-like relationship. Second, the dataset is a longitudinal prospective cohort dataset. This enabled us to employ instrumental variable estimation to account for the influence of unobserved factors and give proper time order. With this, this study revealed a substantive relationship between SEM exposure and risky sexual behavior. In addition, we checked the results by using models with more strict distributional assumptions (e.g., a bivariate probit model) and came to similar conclusions. Hence, we have some confidence that the estimated LATE is very close to the ATE. Furthermore, the analyses controlled for a variety of confounders such as health status, depressive symptoms and dating experience as well as school fixed effects to alleviate the influence of possible omitted variable bias. This gives us opportunities to examine similar results related to adolescent reproductive health in various cultures.

While the present results do provide invaluable insight into how sexually explicit media exposure affects later risky sexual behavior, some caveats must be addressed. First, the measurement of sexually explicit media exposure did not include frequency of exposure. Furthermore, the measure was static; hence, dynamic changes between sexually explicit media exposure and risky sexual behavior could not be explored [117]. Second, our measure of SEM included mostly non-Internet related media. This may provoke some concern when applying the results to the current era. To some extent, this may be a limitation to this study; however, given this study was conducted at the beginning of the surge in Internet usage, a limited measure of SEM exposure is understood. Although the Internet becomes the main media for entertainment and a main resource for SEM content, the influence of SEM from traditional media on risky sexual behaviors are continually found [20]. Hence, this limitation may not be a serious threat to the current study. However, discussion of three scenarios is worthwhile. First, given the vivid depiction of SEM on-line and becomes more "interactional," our estimated effects of SEM from traditional media on risky sexual behaviors may be an underestimation of media effects. Second, Internet media usage may lead to reduced actual social contact, which may reduce sexual behaviors. For example, heavy Internet/problematic internet use may be related to lethargic negative emotions (i.e., loneliness and depression) [118], which can lead to lower levels of sexual activities. In this case, exposure to SEM on the Internet may reduce sexual behavior, in general, and risky sexual behavior, in particular; hence, our estimation may be overestimated. Third, one study has shown that dating applications (App) actually did not increase the possibility of building long-term romantic relationships, which may provide sexual opportunities. However, these Apps increased one kind of risky sexual behavior-casual sex (i.e., hook-up) [119]. In this final scenario, the effects of the Internet on risky sexual behaviors is positive but may be negative for general sexual behavior. While these are only some explanations and speculations, future studies should consider these issues.

Second, the requirement that the IV be uncorrelated with the second-stage error term can never be completely validated in empirical studies. The statistical analyses did show that the IV was reasonable, but this remains open to critique. For instance, although some studies have shown that pubertal timing is not related to later risky sexual behaviors [120–121], others have shown a partial relationship [122–123]. Hence, one may argue that there may be a direct link between pubertal timing and later risky sexual behavior. However, many previous studies did not consider the possible underlying mechanism linking pubertal timing and later risky sexual behavior (e.g., SEM exposure) and have indicated that the effects of early puberty on later behavior may be short-lived because all individuals eventually experience this change in young adulthood [122,124]. Given that we estimated the long-term effects of SEM exposure on risky sexual behaviors, we have some confidence in our IVs. Furthermore, the present results also demonstrated that the possible long-term effect of pubertal timing on risky sexual behavior is

through SEM exposure (See Table 2 for the insignificant effect of pubertal timing on risky sexual behavior when controlling for SEM exposure). This result relieved the concern that pubertal timing has a direct and long-term effect on risky sexual behavior. Third, our outcome variable was limited to the three often used risky sexual behaviors; hence, our results may not be applicable to risky sexual behaviors other than these three risky sexual behavior. However, previous studies have shown that SEM exposure was significantly related to other risky sexual behavior or related outcomes, such as casual sex [31] and paid sex or group sex [125]. Fourth, all results were based on a self-report; consequently, reporting biases might have influenced the current results.

Medical and health researchers often argue that early prevention is a more efficient and better method of combating later diseases. Given the strong relationship between SEM exposure and risky sexual behaviors found in the present study, preventive strategies regarding SEM exposure should be implemented early in life, possibly before or at the start of puberty. This suggestion is corroborated by the American Academy of Pediatrics that indicated that early adolescence is the time to start sexuality discussions [126]. One possible preventive strategy is to cultivate adolescents' media literacy, such as content literacy (i.e., knowledge about the ideas and contents presented in the media) and grammar literacy (i.e., knowledge of the techniques used to present visual content in the media, such as angles and zooms) [127]. To instill content literacy, officials (e.g., pediatricians and school teachers) and parents can take the initiative to provide adolescents with appropriate information on sexuality (e.g., ways of reducing sexual risk). To enhance grammar literacy, parents and school officials can help children decipher the scripts in SEM and "propagate" correct scripts (e.g., negative consequences of unsafe or casual sex). One recent review showed that a media literacy intervention was effective in preventing the negative impact of media on risky adolescent behavior [127]. In addition, sex education implementing positive information, such as preventive (e.g., risk avoidance) and protective behaviors (e.g., STIs protection), may have a great impact on adolescent sexual health. In fact, one study showed that receiving correct information enhanced individuals' protective actions against future risky behaviors [128]. However, given the sensitive nature of these topics, before school officials and parents aim to cultivate adolescents' media literacy or provide sex-related information, confidentiality between the two parties must be established [129]. Finally, aside from our main finding, our first-stage of 2SLS results showed that family cohesion is related to a lower probability of SEM exposure; hence, encouraging parents to establish a warm and mutually supportive family atmosphere may help to reduce SEM exposure, which in turn can help in reducing future sexual risk taking.

Conclusion

Two important results emerged from this study. First, sexually explicit media exposure in early adolescence was strongly related to three risky sexual behaviors—early sexual debut, unsafe sex, and sexual partners—in late adolescence, and this relationship was very close to causal. Second, the association was dose-response, such that using more modalities of sexually explicit media led to a higher probability of being involved in risky sexual behavior later in life. Given that the negative consequences of risky sexual behaviors (e.g., STIs and unplanned pregnancy) have tremendous social costs in both Western and Asian societies, it is necessary to implement preventive strategies early on.

Supporting information

S1 Appendix.
(DOCX)

S2 Appendix.
(DOCX)

S3 Appendix.
(DOCX)

Author Contributions

Conceptualization: Wen-Hsu Lin.

Data curation: Wen-Hsu Lin, Chia-Hua Liu, Chin-Chun Yi.

Formal analysis: Chia-Hua Liu.

Funding acquisition: Wen-Hsu Lin.

Investigation: Chia-Hua Liu.

Methodology: Chia-Hua Liu.

Resources: Chin-Chun Yi.

Supervision: Chin-Chun Yi.

Validation: Chin-Chun Yi.

Writing – original draft: Wen-Hsu Lin.

Writing – review & editing: Wen-Hsu Lin.

Reference

1. Simons LG, Sutton TE, Simons RL, Gibbons FX, Murry VM. Mechanisms that link parenting practices to adolescents' risky sexual behavior: A test of six competing theories. J Youth Adolesc 2016 Feb; 45 (2): 255–70. https://doi.org/10.1007/s10964-015-0409-7 PMID: 26718543

2. Moilanen KL, Crockett LJ, Raffaelli M, Jones BL. Trajectories of sexual risk from middle adolescence to early adulthood. J Res Adolesc 2010 Mar; 20(1): 114–39. https://doi.org/10.1111/j.1532-7795.2009.00628.x

3. Sandfort TG, Orr M, Hirsch JS, Santelli J. Long-term health correlates of timing of sexual debut: Results from a national US study. Am J Public Health 2008 Jan; 98(1): 155–61. https://doi.org/10.2105/AJPH.2006.097444 PMID: 18048793

4. WHO. Brief sexuality-related communication: Recommendations for a public health approach 2015. Geneva: World Health Organization; 2015.

5. Chandra A, Martino SC, Collins RL, Elliott MN, Berry SH, Kanouse DE, et al. Does watching sex on television predict teen pregnancy? Findings from a national longitudinal survey of youth. Pediatrics 2008 Nov; 122(5): 1047–54. https://doi.org/10.1542/peds.2007-3066 PMID: 18977986

6. Erkut S, Grossman JM, Frye AA, Ceder I, Charmaraman L, Tracy AJ. Can sex education delay early sexual debut?. J Early Adolesc 2013 May; 33(4): 482–97. https://doi.org/10.1177/0272431612449386

7. Escobar-Chaves SL, Tortolero SR, Markham CM, Low BJ, Eitel P, Thickstun P. Impact of the media on adolescent sexual attitudes and behaviors. Pediatrics-English Edition 2005 Jul; 116(1): 303–26. https://doi.org/10.1542/peds.2005-0355D PMID: 16001458

8. CDC, Taiwan. Taiwan National Infectious Disease Statistic System [Internet]. https://nidss.cdc.gov.tw/en/ Cited 10 June 2019

9. Sawyer SM, Afifi RA, Bearinger LH, Blakemore SJ, Dick B, Ezeh AC, et al. Adolescence: a foundation for future health. Lancet 2012 Apr; 379(9826): 1630–40. https://doi.org/10.1016/S0140-6736(12)60072-5 PMID: 22538178

10. Lyerly JE, Huber LR. The role of family conflict on risky sexual behavior in adolescents aged 15 to 21. Ann Epidemiol 2013 Apr; 23(4): 233–5. https://doi.org/10.1016/j.annepidem.2013.01.005 PMID: 23415277

11. Simons LG, Simons RL, Lei MK, Sutton TE. Exposure to harsh parenting and pornography as explanations for males' sexual coercion and females' sexual victimization. Violence Vict 2012 Jan; 27(3): 378–95. https://doi.org/10.1891/0886-6708.27.3.378 PMID: 22852438

12. Lansford JE, Yu T, Erath SA, Pettit GS, Bates JE, Dodge KA. Developmental precursors of number of sexual partners from ages 16 to 22. J Res Adolesc 2010 Sep; 20(3): 651–77. https://doi.org/10.1111/j.1532-7795.2010.00654.x PMID: 20823951

13. De Graaf H, Van de Schoot R, Woertman L, Hawk ST, Meeus W. Family cohesion and romantic and sexual initiation: A three wave longitudinal study. J Youth Adolesc 2012 May; 41(5): 583–92. https://doi.org/10.1007/s10964-011-9708-9 PMID: 21853354

14. Jessor R, Jessor S. L. Problem behavior and psychosocial development. New York: Academic Press; 1977.

15. Bailey JA, Hill KG, Meacham MC, Young SE, Hawkins JD. Strategies for characterizing complex phenotypes and environments: General and specific family environmental predictors of young adult tobacco dependence, alcohol use disorder, and co-occurring problems. Drug Alcohol Depend 2011 Nov; 118(2–3): 444–51. https://doi.org/10.1016/j.drugalcdep.2011.05.002 PMID: 21636226

16. Choudhry V, Agardh A, Stafström M, Östergren PO. Patterns of alcohol consumption and risky sexual behavior: a cross-sectional study among Ugandan university students. BMC Public Health 2014 Dec; 14(1): 128. https://doi.org/10.1186/1471-2458-14-128 PMID: 24502331

17. Hirschi T. Causes of delinquency. Berkeley: University of California Press; 1969.

18. Parkes A, Waylen A, Sayal K, Heron J, Henderson M, Wight D, et al. Which behavioral, emotional and school problems in middle-childhood predict early sexual behavior?. J Youth Adolesc 2014 Apr; 43 (4): 507–27. https://doi.org/10.1007/s10964-013-9973-x PMID: 23824981

19. Van Ryzin MJ, Johnson AB, Leve LD, Kim HK. The number of sexual partners and health-risking sexual behavior: Prediction from high school entry to high school exit. Arch Sex Behav 2011 Oct; 40(5): 939–49. https://doi.org/10.1007/s10508-010-9649-5 PMID: 20703789

20. O'Hara RE, Gibbons FX, Gerrard M, Li Z, Sargent JD. Greater exposure to sexual content in popular movies predicts earlier sexual debut and increased sexual risk taking. Psychol Sci 2012 Sep; 23(9): 984–93. https://doi.org/10.1177/0956797611435529 PMID: 22810165

21. Wright PJ. Pornography consumption, cocaine use, and casual sex among U.S. adults. Psychol Rep 2012 Aug; 111(1): 305–310. https://doi.org/10.2466/18.02.13.PR0.111.4.305-310 PMID: 23045873

22. Atwood KA, Kennedy SB, Shamblen S, Taylor CH, Quaqua M, Bee EM, et al. Reducing sexual risk taking behaviors among adolescents who engage in transactional sex in post-conflict Liberia. Vulnerable Child Youth Stud 2012 Mar; 7(1): 55–65. https://doi.org/10.1080/17450128.2011.647773 PMID: 23626654

23. Strasburger VC, Wilson BJ, Jordan AB. Children, adolescents, and the media. 3rd ed. CA: Sage; 2014.

24. Wright PJ, Vangeel L. Pornography, permissiveness, and sex differences: An evaluation of social learning and evolutionary explanations. Pers Individ Differ 2019 Jun; 143: 128–38. https://doi.org/10.1016/j.paid.2019.02.019

25. Peter J, Valkenburg PM. The use of sexually explicit internet material and its antecedents: A longitudinal comparison of adolescents and adults. Arch Sex Behav 2011 Oct; 40(5): 1015–1025. https://doi.org/10.1007/s10508-010-9644-x PMID: 20623250

26. Ybarra ML, Mitchell KJ, Hamburger M, Diener-West M, Leaf PJ. X-rated material and perpetration of sexually aggressive behavior among children and adolescents: is there a link? Aggress Behav 2011 Jan-Feb; 37(1): 1–18. https://doi.org/10.1002/ab.20367 PMID: 21046607

27. Comstock G, Strasburger VC. Media violence: Q & A. Adolesc Med State Art Rev 1993 Oct; 4(3): 495–510. PMID: 10356228

28. Harkness EL, Mullan B, Blaszczynski A. Association between pornography use and sexual risk behaviors in adult consumers: a systematic review. Cyberpsychol Behav Soc Netw 2015 Feb; 18(2): 59–71. https://doi.org/10.1089/cyber.2014.0343 PMID: 25587721

29. Owens EW, Behun RJ, Manning JC, Reid RC. The impact of Internet pornography on adolescents: A review of the research. Sex Addict Compulsivity 2012 Jan; 19(1–2): 99–122. https://doi.org/10.1080/10720162.2012.660431

30. Willoughby BJ, Young-Petersen B, Leonhardt ND. Exploring trajectories of pornography use through adolescence and emerging adulthood. J Sex Res 2018 Mar; 55(3): 297–309. https://doi.org/10.1080/00224499.2017.1368977 PMID: 28972398

31. Morgan EM. Associations between young adults' use of sexually explicit materials and their sexual preferences, behaviors, and satisfaction. J Sex Res 2011 Nov; 48(6): 520–30. https://doi.org/10.1080/00224499.2010.543960 PMID: 21259151

32. Sinković M, Štulhofer A, Božić J. Revisiting the association between pornography use and risky sexual behaviors: The role of early exposure to pornography and sexual sensation seeking. J Sex Res 2013 Oct; 50(7): 633–41. https://doi.org/10.1080/00224499.2012.681403 PMID: 22853694

33. Kraus SW, Russell B. Early sexual experiences: The role of intranet access and sexually explicit material. CyberPsychol Behav 2008 April; 11(2):162–168. https://doi.org/10.1089/cpb.2007.0054 PMID: 18422408

34. Bushman BJ, Cantor J. Media ratings for violence and sex: Implications for policymakers and parents. Am Psychol 2003 Feb; 58(2):130. https://doi.org/10.1037/0003-066x.58.2.130 PMID: 12747015

35. Kubicek K, Beyer WJ, Weiss G, Iverson E, Kipke MD. In the dark: Young men's stories of sexual initiation in the absence of relevant sexual health information. Health Educ Behav 2010 Apr; 37(2): 243–63. https://doi.org/10.1177/1090198109339993 PMID: 19574587

36. Ybarra ML, Strasburger VC, Mitchell KJ. Sexual media exposure, sexual behavior, and sexual violence victimization in adolescence. Clin Pediatr 2014 Nov; 53(13): 1239–47. https://doi.org/10.1177/0009922814538700 PMID: 24928575

37. Kohut T, Baer JL, Watts B. Is pornography really about "making hate to women"? Pornography users hold more gender egalitarian attitudes than nonusers in a representative American sample. J Sex Res 2016 Jan; 53(1): 1–1. https://doi.org/10.1080/00224499.2015.1023427 PMID: 26305435

38. Grudzen CR, Elliott MN, Kerndt PR, Schuster MA, Brook RH, Gelberg L. Condom use and high-risk sexual acts in adult films: A comparison of heterosexual and homosexual films. Am J Public Health 2009 Apr; 99(1): S152–6. https://doi.org/10.2105/AJPH.2007.127035 PMID: 19218178

39. Sun C, Bridges A, Johnson JA, Ezzell MB. Pornography and the male sexual script: An analysis of consumption and sexual relations. Arch Sex Behav 2016 May; 45(4): 983–94. https://doi.org/10.1007/s10508-014-0391-2 PMID: 25466233

40. Svedin CG, Åkerman I, Priebe G. Frequent users of pornography. A population based epidemiological study of Swedish male adolescents. J Adolesc 2011 Aug; 34(4): 779–88. https://doi.org/10.1016/j.adolescence.2010.04.010 PMID: 20888038

41. Vandenbosch L, Eggermont S. Sexually explicit websites and sexual initiation: Reciprocal relationships and the moderating role of pubertal status. J Res Adolesc 2013 Dec; 23(4): 621–34. https://doi.org/10.1111/jora.12008

42. Braun-Courville DK, Rojas M. Exposure to sexually explicit web sites and adolescent sexual attitudes and behaviors. J Adolesc Health 2009 Aug; 45(2): 156–62. https://doi.org/10.1016/j.jadohealth.2008.12.004 PMID: 19628142

43. O'Hara RE, Gibbons FX, Li Z, Gerrard M, Sargent JD. Specificity of early movie effects on adolescent sexual behavior and alcohol use. Soc Sci Med 2013 Nov; 96: 200–7. https://doi.org/10.1016/j.socscimed.2013.07.032 PMID: 24034968

44. Koletić G, Kohut T, Štulhofer A. Associations between adolescents' use of sexually explicit material and risky sexual behavior: A longitudinal assessment. PloS One 2019 Jun; 14(6): e0218962. https://doi.org/10.1371/journal.pone.0218962 PMID: 31242258

45. Lim MS, Agius PA, Carrotte ER, Vella AM, Hellard ME. Young Australians' use of pornography and associations with sexual risk behaviours. Aust NZ J Publ Heal 2017 Aug; 41(4): 438–43. https://doi.org/10.1111/1753-6405.12678 PMID: 28664609

46. Luder MT, Pittet I, Berchtold A, Akré C, Michaud PA, Surís JC. Associations between online pornography and sexual behavior among adolescents: Myth or reality?. Arch Sex Behav 2011 Feb; 40(5): 1027–35. https://doi.org/10.1007/s10508-010-9714-0 PMID: 21290259

47. Matković T, Cohen N, Štulhofer A. The use of sexually explicit material and its relationship to adolescent sexual activity. J Adolesc Health 2018 May; 62(5): 563–9. https://doi.org/10.1016/j.jadohealth.2017.11.305 PMID: 29503032

48. Ybarra ML, Mitchell KJ. "Sexting" and its relation to sexual activity and sexual risk behavior in a national survey of adolescents. J Adolesc Health 2014 Dec; 55(6): 757–64. https://doi.org/10.1016/j.jadohealth.2014.07.012 PMID: 25266148

49. Collins RL, Martino SC, Elliott MN, Miu A. Relationships between adolescent sexual outcomes and exposure to sex in media: Robustness to propensity-based analysis. Dev Psychol 2011 Mar; 47(2): 585. https://doi.org/10.1037/a0022563 PMID: 24839301

50. Brown JD, Steele JR, Walsh-Childers K (ed.). Sexual teens, sexual media: Investigating media's influence on adolescent sexuality. Routledge; 2001.

51. Tolman DL, McClelland SI. Normative sexuality development in adolescence: A decade in review, 2000–2009. J Res Adolesc 2011 Mar; 21(1): 242–55. https://doi.org/10.1111/j.1532-7795.2010.00726.x

52. Angrist JD, Imbens GW, Rubin DB. Identification of causal effects using instrumental variables. J Am Stat Assoc 1996 Jun; 91(434): 444–55. https://doi.org/10.2307/2291629

53. Sun X, Liu X, Shi Y, Wang Y, Wang P, Chang C. Determinants of risky sexual behavior and condom use among college students in China. AIDS Care 2013 May; 25(6): 775–83. https://doi.org/10.1080/09540121.2012.748875 PMID: 23252705

54. Lo VH, Wei R. Exposure to Internet pornography and Taiwanese adolescents' sexual attitudes and behavior. J Broadcast Electron Media 2005 Jun; 49(2): 221–37. https://doi.org/10.1080/01614576.1987.11074908

55. Kim YH. Korean adolescents' health risk behaviors and their relationships with the selected psychological constructs. J Adolesc Health 2001 Oct; 29(4): 298–306. https://doi.org/10.1016/s1054-139x(01)00218-x PMID: 11587914

56. Ma CM, Shek DT. Consumption of pornographic materials in early adolescents in Hong Kong. J Pediatr Adolesc Gynecol 2013 Jun; 26(3): S18–25. https://doi.org/10.1016/j.jpag.2013.03.011 PMID: 23683822

57. Braun-Courville DK, Rojas M. Exposure to sexually explicit web sites and adolescent sexual attitudes and behaviors. J Adolesc Health 2009 Aug; 45(2): 156–62. https://doi.org/10.1016/j.jadohealth.2008.12.004 PMID: 19628142

58. Sabina C, Wolak J, Finkelhor D. The nature and dynamics of Internet pornography exposure for youth. CyberPsychol Behav 2008 Dec; 11(6): 691–3. https://doi.org/10.1089/cpb.2007.0179 PMID: 18771400

59. Häggström-Nordin E, Hanson U, Tydén T. Associations between pornography consumption and sexual practices among adolescents in Sweden. Int J STD AIDS 2005 Feb; 16(2): 102–7. https://doi.org/10.1258/0956462053057512 PMID: 15807936

60. Weber M, Quiring O, Daschmann G. Peers, parents and pornography: Exploring adolescents' exposure to sexually explicit material and its developmental correlates. Sex Cult 2012 Dec; 16(4): 408–27. https://doi.org/10.1007/s12119-012-9132-7

61. Rissel C, Richters J, De Visser RO, McKee A, Yeung A, Caruana T. A profile of pornography users in Australia: Findings from the second Australian study of health and relationships. J Sex Res 2017 Feb; 54(2): 227–40. https://doi.org/10.1080/00224499.2016.1191597 PMID: 27419739

62. Spriggs AL, Halpern CT. Timing of sexual debut and initiation of postsecondary education by early adulthood. Perspect Sex Reprod Health 2008 Sep; 40(3): 152–61. https://doi.org/10.1363/4015208 PMID: 18803797

63. Buttmann N, Nielsen A, Munk C, Frederiksen K, Liaw KL, Kjaer SK. Young age at first intercourse and subsequent risk-taking behaviour: An epidemiological study of more than 20,000 Danish men from the general population. Scand J Public Health 2014 Aug; 42(6): 511–7. https://doi.org/10.1177/1403494814538123 PMID: 24906552

64. Heywood W, Patrick K, Smith AM, Pitts MK. Associations between early first sexual intercourse and later sexual and reproductive outcomes: a systematic review of population-based data. Arch Sex Behav 2015 Apr; 44(3): 531–69. https://doi.org/10.1007/s10508-014-0374-3 PMID: 25425161

65. Velezmoro R, Negy C, Livia J. Online sexual activity: Cross-national comparison between United States and Peruvian college students. Arch Sex Behav 2012 Aug; 41(4): 1015–25. https://doi.org/10.1007/s10508-011-9862-x PMID: 22083655

66. Yu XM, Guo SJ, Sun YY. Sexual behaviours and associated risks in Chinese young people: a meta-analysis. Sex Health 2013 Nov; 10(5): 424–33. https://doi.org/10.1071/SH12140 PMID: 23962473

67. Jeong S, Cha C, Lee J. The effects of STI education on Korean adolescents using smartphone applications. Health Educ J 2017 Nov; 76(7): 775–86. https://doi.org/10.1177/0017896917714288

68. Hong JS, Voisin DR, Hahm HC, Feranil M, Mountain SA. A review of sexual attitudes, knowledge, and behaviors Among South Korean early adolescents: Application of the ecological framework. J Soc Serv Res 2016 Oct; 42(5): 584–97. https://doi.org/10.1080/01488376.2016.1202879

69. James J, Ellis BJ, Schlomer GL, Garber J. Sex-specific pathways to early puberty, sexual debut, and sexual risk taking: Tests of an integrated evolutionary–developmental model. Dev Psychol 2012 May; 48(3): 687 https://doi.org/10.1037/a0026427 PMID: 22268605

70. Zimmer-Gembeck MJ, Helfand M. Ten years of longitudinal research on US adolescent sexual behavior: Developmental correlates of sexual intercourse, and the importance of age, gender and ethnic background. Dev Rev 2008 Jun; 28(2): 153–224. https://doi.org/10.1016/j.dr.2007.06.001

71. Parkes A, Wight D, Henderson M, West P. Does early sexual debut reduce teenagers' participation in tertiary education? Evidence from the SHARE longitudinal study. J Adolesc 2010 Oct; 33(5): 741–54. https://doi.org/10.1016/j.adolescence.2009.10.006 PMID: 19897236

72. Baumann P, Bélanger RE, Akre C, Suris JC. Increased risks of early sexual initiators: time makes a difference. Sex Health 2011 Sep; 8(3): 431–5. https://doi.org/10.1071/SH10103 PMID: 21851787

73. Johnson MW, Bruner NR. The Sexual Discounting Task: HIV risk behavior and the discounting of delayed sexual rewards in cocaine dependence. Drug Alcohol Depend 2012 Jun; 123(1–3):15–21. https://doi.org/10.1016/j.drugalcdep.2011.09.032 PMID: 22055012

74. Regushevskaya E, Dubikaytis T, Laanpere M, Nikula M, Kuznetsova O, Karro H, et al. The determinants of sexually transmitted infections among reproductive age women in St. Petersburg, Estonia and Finland. Int J Public Health 2010 Dec; 55(6): 581–9. https://doi.org/10.1007/s00038-010-0161-4 PMID: 20589411

75. Kim HS. Sexual debut and mental health among South Korean adolescents. J Sex Res 2016 Mar; 53 (3): 313–320. https://doi.org/10.1080/00224499.2015.1055855 PMID: 26457545

76. Yeh CC, Lin SH, Zhuang YL. The comparison of the risk of first sexual intercourse among different characteristics of high school students. 21st century Demographic development in Taiwan: Trend and challenge, Taipei, Taiwan; 2005.

77. Ashenhurst JR, Wilhite ER, Harden KP, Fromme K. Number of sexual partners and relationship status are associated with unprotected sex across emerging adulthood. Arch Sex Behav 2017 Feb; 46(2): 419–32. https://doi.org/10.1007/s10508-016-0692-8 PMID: 26940966

78. Finer LB, Philbin JM. Sexual initiation, contraceptive use, and pregnancy among young adolescents. Pediatrics 2013 May; 131(5): 886–91. https://doi.org/10.1542/peds.2012-3495 PMID: 23545373

79. Petersen AC, Crockett L, Richards M, Boxer A. A self-report measure of pubertal status: Reliability, validity, and initial norms. J Youth Adolesc 1988 Apr; 17(2): 117–33. https://doi.org/10.1007/BF01537962 PMID: 24277579

80. Chiao C, Ksobiech K. The influence of early sexual debut and pubertal timing on psychological distress among Taiwanese adolescents. Psychol Health Med 2015 Nov; 20(8): 972–8. https://doi.org/10.1080/13548506.2014.987147 PMID: 25495948

81. Kogan SM, Cho J, Simons LG, Allen KA, Beach SR, Simons RL, et al. Pubertal timing and sexual risk behaviors among rural African American male youth: Testing a model based on life history theory. Arch Sex Behav 2015 Apr; 44(3): 609–18. https://doi.org/10.1007/s10508-014-0410-3 PMID: 25501863

82. Bond L, Clements J, Bertalli N, Evans-Whipp T, McMorris BJ, Patton GC, et al. A comparison of self-reported puberty using the Pubertal Development Scale and the Sexual Maturation Scale in a school-based epidemiologic survey. J Adolesc 2006 Oct; 29(5): 709–20. https://doi.org/10.1016/j.adolescence.2005.10.001 PMID: 16324738

83. Dorn LD, Dahl RE, Woodward HR, Biro F. Defining the boundaries of early adolescence: A user's guide to assessing pubertal status and pubertal timing in research with adolescents. Appl Dev Sci 2006 Jan; 10(1): 30–56. https://doi.org/10.1207/s1532480xads1001_3

84. Natsuaki MN, Klimes-Dougan B, Ge X, Shirtcliff EA, Hastings PD, Zahn-Waxler C. Early pubertal maturation and internalizing problems in adolescence: Sex differences in the role of cortisol reactivity to interpersonal stress. J Clin Child Adolesc Psychol 2009 Jul; 38(4): 513–24. https://doi.org/10.1080/15374410902976320 PMID: 20183638

85. Dimler LM, Natsuaki MN. The effects of pubertal timing on externalizing behaviors in adolescence and early adulthood: A meta-analytic review. J Adolesc 2015 Dec; 45: 160–70. https://doi.org/10.1016/j.adolescence.2015.07.021 PMID: 26439868

86. Tsai MC, Strong C, Lin CY. Effects of pubertal timing on deviant behaviors in Taiwan: a longitudinal analysis of 7th-to 12th-grade adolescents. J Adolesc 2015 Jul; 42: 87–97. https://doi.org/10.1016/j.adolescence.2015.03.016 PMID: 25956430

87. Ministry of Health and Welfare. The final report of 2006 Taiwan Youth Health Survey [Internet]. https://www.hpa.gov.tw/Pages/Detail.aspx?nodeid=257&pid=6558 Cited 5 October 2019

88. Petersen JL, Hyde JS. A meta-analytic review of research on gender differences in sexuality, 1993–2007. Psychol Bull 2010 Jan; 136(1): 21. https://doi.org/10.1037/a0017504 PMID: 20063924

89. Santelli JS, Lowry R, Brener ND, Robin L. The association of sexual behaviors with socioeconomic status, family structure, and race/ethnicity among US adolescents. Am J Public Health 2000 Oct; 90 (10): 1582. https://doi.org/10.2105/ajph.90.10.1582 PMID: 11029992

90. Weiser SD, Leiter K, Bangsberg DR, Butler LM, Percy-de Korte F, Hlanze Z, et al. Food insufficiency is associated with high-risk sexual behavior among women in Botswana and Swaziland. PLoS Med 2007 Oct; 4(10): e260. https://doi.org/10.1371/journal.pmed.0040260 PMID: 17958460

91. Simons LG, Burt CH, Tambling RB. Identifying mediators of the influence of family factors on risky sexual behavior. J Child Fam Stud 2013 May; 22(4): 460–70. https://doi.org/10.1007/s10826-012-9598-9

92. Whiteman SD, Zeiders KH, Killoren SE, Rodriguez SA, Updegraff KA. Sibling influence on Mexican-origin adolescents' deviant and sexual risk behaviors: The role of sibling modeling. J Adolesc Health 2014 May; 54(5): 587–92. https://doi.org/10.1016/j.jadohealth.2013.10.004 PMID: 24287013

93. Lansford JE, Yu T, Erath SA, Pettit GS, Bates JE, Dodge KA. Developmental precursors of number of sexual partners from ages 16 to 22. J Res Adolesc 2010 Sep; 20(3): 651–77. https://doi.org/10.1111/j.1532-7795.2010.00654.x PMID: 20823951

94. De Graaf H, Van de Schoot R, Woertman L, Hawk ST, Meeus W. Family cohesion and romantic and sexual initiation: A three wave longitudinal study. J Youth Adolesc 2012 May; 41(5): 583–92. https://doi.org/10.1007/s10964-011-9708-9 PMID: 21853354

95. Kotchick BA, Shaffer A, Miller KS, Forehand R. Adolescent sexual risk behavior: A multi-system perspective. Clin Psychol Rev 2001 Jun; 21(4): 493–519. https://doi.org/10.1016/s0272-7358(99)00070-7 PMID: 11413865

96. Chiao C, Yi CC. Adolescent premarital sex and health outcomes among Taiwanese youth: perception of best friends' sexual behavior and the contextual effect. AIDS Care 2011 Sep; 23(9): 1083–92. https://doi.org/10.1080/09540121.2011.555737 PMID: 21562995

97. Schuster RM, Mermelstein R, Wakschlag L. Gender-specific relationships between depressive symptoms, marijuana use, parental communication and risky sexual behavior in adolescence. J Youth Adolesc 2013 Aug; 42(8): 1194–209. https://doi.org/10.1007/s10964-012-9809-0 PMID: 22927009

98. Bailey JA, Haggerty KP, White HR, Catalano RF. Associations between changing developmental contexts and risky sexual behavior in the two years following high school. Arch Sex Behav 2011 Oct; 40 (5): 951–60. https://doi.org/10.1007/s10508-010-9633-0 PMID: 20571863

99. Oliveria-Campos M, Giatti L, Malta D, Barreto S. Contextual factors associated with sexual behavior among Brazilian adolescents. Ann Epidemiol 2013 Oct; 23(10):629–635. https://doi.org/10.1016/j.annepidem.2013.03.009 PMID: 23622957

100. Akers RL. Social learning and social structure: A general theory of crime and deviance. Boston: Northwest University Press; 1998.

101. Derogatis LR. SCL-90-R: Administration, Scoring, and Procedures manual−II. 2nd ed. Towson, MD: Leonard R. Derogatis; 1983.

102. Hellevik O. Linear versus logistic regression when the dependent variable is a dichotomy. Qual Quant 2009 Jan; 43(1): 59–74. https://doi.org/10.1007/s11135-007-9077-3

103. Cawley J, Meyerhoefer C. The medical care costs of obesity: an instrumental variables approach. J Health Econ 2012 Jan; 31(1): 219–30. https://doi.org/10.1016/j.jhealeco.2011.10.003 PMID: 22094013

104. Luder MT, Pittet I, Berchtold A, Akré C, Michaud PA, Surís JC. Associations between online pornography and sexual behavior among adolescents: Myth or reality?. Arch Sex Behav 2011 Oct; 40(5): 1027–35. https://doi.org/10.1007/s10508-010-9714-0 PMID: 21290259

105. McKee A. Does pornography harm young people?. Aust J Commun 2010 Jan; 37(1): 17–36. Available from: http://eprints.qut.edu.au/41858/

106. Stock JH, Wright JH, Yogo M. A survey of weak instruments and weak identification in generalized method of moments. J Bus Econ Stat 2002 Oct; 20(4): 518–29. https://doi.org/10.1198/073500102288618658

107. Ellis BJ. Timing of pubertal maturation in girls: an integrated life history approach. Psychol Bull 2004 Nov; 130(6): 920. https://doi.org/10.1037/0033-2909.130.6.920 PMID: 15535743

108. Rowe DC. On genetic variation in menarche and age at first sexual intercourse: A critique of the Belsky–Draper hypothesis. Evol Hum Behav 2002 Sep; 23(5): 365–72. https://doi.org/10.1016/S1090-5138(02)00102-2

109. Kaprio J, Rimpelä A, Winter T, Viken RJ, Rimpelä M, Rose RJ. Common genetic influences on BMI and age at menarche. Hum Biol 1995 Oct: 739–53. PMID: 8543288

110. Hansen LP. Large sample properties of generalized method of moments estimators. Econometrica: J Econom Soc 1982 Jul: 1029–54. https://doi.org/10.2307/1912775

111. Angrist J, Imbens G. Identification and estimation of local average treatment effects. Econometrica 1995; 62: 467–475. https://doi.org/10.3386/t0118

112. WHO. Sexual and reproductive health [Internet]. https://www.who.int/reproductivehealth/topics/adolescence/en/ Cited 5 October 2019.

113. Bandura A. Social foundations of thought and action. Englewood Cliffs, NJ: Prentice Hall; 1986.

114. Wright PJ. Mass media effects on youth sexual behavior assessing the claim for causality. Ann Int Commun Assoc. 2011 Jan; 35(1): 343–85. https://doi.org/10.1080/23808985.2011.11679121

115. Felitti VJ, Anda RF, Nordenberg D, Williamson DF, Spitz AM, Edwards V, et al. Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults: The Adverse

Childhood Experiences (ACE) Study. Am J Prev Med 1998 May; 14(4): 245–58. https://doi.org/10.1016/S0749-3797(98)00017-8 PMID: 9635069

116. Kim SS, Jang H, Chang HY, Park YS, Lee DW. Association between childhood adversities and adulthood depressive symptoms in South Korea: Results from a nationally representative longitudinal study. BMJ Open 2013; 3: e002680. http://dx.doi.org/10.1136/bmjopen-2013-002680 PMID: 23878171

117. Willoughby BJ, Young-Petersen B, Leonhardt ND. Exploring trajectories of pornography use through adolescence and emerging adulthood. J Sex Res 2018 Mar; 55(3): 297–309. https://doi.org/10.1080/00224499.2017.1368977 PMID: 28972398

118. Tokunaga RS. A meta-analysis of the relationships between psychosocial problems and internet habits: Synthesizing internet addiction, problematic internet use, and deficient self-regulation research. Commun Monogr 2017 Jun; 84(4): 423–446. https://doi.org/10.1080/03637751.2017.1332419

119. The Atlantic. Why are young people having so little sex? [Internet]. https://www.theatlantic.com/magazine/archive/2018/12/the-sex-recession/573949/ Cited 5 October 2019.

120. Ostovich JM, Sabini J. Timing of puberty and sexuality in men and women. Arch Sex Behav 2005 Apr; 34(2): 197–206. https://doi.org/10.1007/s10508-005-1797-7 PMID: 15803253

121. Siebenbruner J, Zimmer-Gembeck MJ, Egeland B. Sexual partners and contraceptive use: A 16-year prospective study predicting abstinence and risk behavior. J Res Adolesc 2007 Mar; 17(1): 179–206. https://doi.org/10.1111/j.1532-7795.2007.00518.x

122. Copeland W, Shanahan L, Miller S, Costello EJ, Angold A, Maughan B. Do the negative effects of early pubertal timing on adolescent girls continue into young adulthood?. Am J Psychiatry 2010 Oct; 167(10): 1218. https://doi.org/10.1176/appi.ajp.2010.09081190

123. Moore SR, Harden KP, Mendle J. Pubertal timing and adolescent sexual behavior in girls. Dev Psychol 2014 Jun; 50(6): 1734. https://doi.org/10.1037/a0036027 PMID: 24588522

124. Weichold K, Silbereisen RK, Schmitt-Rodermund E, Short-term and long-term consequences of early versus late physical maturation in adolescents. In: Hayward C., Editor. Gender differences at puberty. New York, NY: Cambridge University Press; 2003. pp. 241–76.

125. Hald GM, Kuyper L, Adam PC, Wit JB. Does viewing explain doing? Assessing the association between sexually explicit materials use and sexual behaviors in a large sample of Dutch adolescents and young adults. J Sex Med 2013 Dec; 10(12), 2986–2995. https://doi.org/10.1111/jsm.12157 PMID: 23621804

126. Hagan JF, Shaw JS, Duncan PM (ed.). Bright futures: Guidelines for health supervision of infants, children, and adolescents. American Academy of Pediatrics; 2007.

127. Jeong SH, Cho H, Hwang Y. Media literacy interventions: A meta-analytic review. J Commun 2012 Apr; 62(3): 454–72. https://doi.org/10.1111/j.1460-2466.2012.01643.x PMID: 22736807

128. Fedor TM, Kohler HP, Behrman JR. The impact of married individuals learning HIV status in Malawi: divorce, number of sexual partners, and condom use with spouses. Demography 2015 Feb; 52(1): 259–80. https://doi.org/10.1007/s13524-014-0364-z PMID: 25582891

129. Alexander SC, Fortenberry JD, Pollak KI, Bravender T, Davis JK, Østbye T, et al. Sexuality talk during adolescent health maintenance visits. JAMA Pediatr 2014 Feb; 168(2): 163–9. https://doi.org/10.1001/jamapediatrics.2013.4338 PMID: 24378686