Without a Right to Abortion: The Impact of Hormonal Contraception on Teen Suicide

Kelly Suzanne Ragan*
Stockholm School of Economics

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Access to modern fertility control methods such as hormonal contraception (HC) impact women's health and well-being in many ways. Yet, little is known about how the pill's introduction altered the incidence of suicide among adolescent girls, a potential side effect of HC use reported in recent epidemiological studies. This paper studies how the diffusion of HC after approval for contraceptive use is associated with changes in the incidence of suicide among young women in Sweden. Although HC sales increased rapidly, with over a quarter of fecund females using some form of HC on an annual basis within five years of HC's approval for contraceptive use, and over half of teenage girls a decade later, data from death registers following cohorts of Swedish women born since 1941 reveal no evidence of a positive correlation between the pill's diffusion across markets and time and the occurrence of suicide and accidental poisonings among teenage girls.

1 Historical Setting and Related Literature

Fertility control and female mortality have a long history in the Swedish medical literature. Hedren (1901) analyzed autopsy records from suspected suicides in Sweden, documenting the high prevalence of unmarried women in the later stages of pregnancy among these cases. Poisoning, a means to induce miscarriage, often led to death. From 1851-1903 there were 1,408 cases of poisoning by phosphorus suspected to be for the purpose of inducing miscarriage, according to Tillhagen (1983), who argues that such statistics understate the incidence of such fatal poisonings.[1] The widespread occurrence of phosphorus poisonings in Sweden led to a ban on the sale of matchsticks that contained phosphorus starting in 1901. This is but one example of the many means women resorted to for the purpose of inducing miscarriage that often led to death, and a broader phenomenon of women taking their own lives in the face of unwanted pregnancy in 19th and early 20th century Sweden.

Although fertility control measures improved over subsequent decades, oral contraception ('the pill') marked a significant advance for Swedish women. The pill was widely adopted by teens as medical studies such as Sjövall (1972) suggest. Survey evidence from Lewin (2000) documents the pill's rapid rise in popularity among Swedish women. The pill was the third most popular method for preventing pregnancy already five years after approval for contraceptive use, surpassed only by condoms and interrupted intercourse as a means of preventing pregnancy. HC spread rapidly among young women after approval for use by Socialstyrelsen at the end of August 1964. The first full year of HC availability was 1965, and within less than half a decade a quarter of fecund females were using HC, and half of teenage girls by 1979, the first period age specific HC use was reported by Socialstyrelsen (1984).

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[1]Of these cases only ten women survived according to Tillhagen (1983).

The pill's introduction in Sweden provides a unique natural experiment from which to estimate the impact of HC sales on teen mortality. Although women as young as 15 had access to contraceptive services irrespective of their marital status when the pill was introduced in Sweden, abortion rights were restricted. Swedish women did not have a right to abortion until 1975 when the Abortion Act went into effect. Before 1975, a national abortion ban made abortion illegal except in limited circumstances. An onerous petition process required women to apply for exemptions to the national abortion ban from a medical board. Physicians began to sidestep these regulations in the years just before the national abortion ban was lifted, leading to an increase in the prevalence of abortion among women including teens. In contrast, abortion rights had existed in Denmark for a quarter of a century at the start of Skovlund et al's (2018) sample frame 1996 to 2013. During the period they study, HC was a mature technology among many modern contraceptive methods available to young women for the safe and effective control of fertility.

The natural experiment design I adopt has the advantage of a representative control group in the form of women who came of age just before HC was approved. Epidemiological studies compare HC users to the self-selected group of never-users or women who had yet to begin HC use, see Vessey et al (1989), Beral et al (1999), Colditz (1994), Hannaford et al (2010), Charlton et al (2014), and Skovlund et al (2018). Among these studies only Charlton et al (2014) and Skovlund et al (2018) find a significant association between HC use and suicide, and only Skovlund et al (2018) emphasize the outsize importance of HC among adolescents.

The magnitude of the estimates Skovlund et al (2018) report are large. HC use among teens is associated with a doubling of their relative risk to attempt suicide compared to never users of HC. For women overall, HC use is associated with a relative risk of over 3 for committing suicide. The concentration of negative effects among women under 20 is of particular concern in Sweden and Nordic countries where HC use is heavily skewed toward teens (Sjövall (1972), Socialstyrelsen (1984), Skjeldestad (1994)). Coupling these large estimates from Denmark with the pill's rapid and expansive take-up in Sweden, especially among teens, frames the question examined in this study. Did the introduction of the pill in Sweden lead to a suicide epidemic among teens? To answer this I compare cohorts of women who come of age before and after the pill, across time and markets, to investigate the pill's impact on teen suicide and accidental poisonings.

The treatment measure I use differs from the epidemiological literature. I do not use individual HC use, but instead local market level exposure by year as captured by sales per woman aged 15-44 in a given market and time period. HC sales provide a complete measure of HC use, but they cannot be disaggregated at the individual level or by age. Individual prescription data does not exist in this time period, but the results of this analysis have clear relevance to public health policy. The paper studies

an alternative setting where abortion was not a right and teens had few options for effective and reliable contraception, complementing and assessing the sensitivity of the epidemiological findings.

Although epidemiological studies provide an important point of comparison, the contribution of this study goes beyond implementing an alternative study design in a different time period. By recasting the current medical debate in a historical setting where women lacked a right to abortion, my study has potential relevance for settings where abortion rights are restricted. By estimating the relationship between suicide among teens and the pill's diffusion in a setting where women lacked a right to abortion, I elevate the important role institutional factors may play in shaping estimates. The biological channels Skovlund et al (2018) emphasize where hormonal contraceptive use leads to depression and in turn suicide, a causal mechanism which they argue adolescent women are more sensitive to, may also be at work in Sweden in the decade following the introduction of HC. Yet, the aggregate data do not reveal a positive correlation between local HC sales and suicide among teens. Although the varieties of HC available in Sweden had greater hormonal content than those studied by Skovlund et al (2018) the aggregate effect of HC's rapid and ubiquitous diffusion is not distinguishable from zero, and is not consistent with the large positive relationship suggested in Skovlund et al (2018).

2   Hormonal Contraceptive Sales and Teen Suicide Data

I compile rich data on HC sales from the *Swedish Drug Market* (SDM) publication.[2] SDM reports the entire universe of HC sales starting in 1965 and disaggregated across 70 geographically defined markets (A-regions) starting in 1970. Detailed data on HC sales, pricing, market shares, and hormone content of the leading brands are presented in Table 1.

HC sales data imply annual use estimates which conform closely to the prescription data plotted (dash) in Figure 1, from Socialstyrelsen (1984), confirming the rapid adoption of HC among Swedish women.[3] Suicides per 100,000 teens in high HC sales markets (dark blue) and low HC markets (light blue) are plotted from 1961-79.[4] Abortions per 1000 teens are also plotted (light dash).[5] A close correspondence

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[2]Läkemedelstatistik A.B., a consortium of drug wholesalers, published the SDM. Sales are reported in Swedish Kronor (SEK), though the analysis uses sales expressed in 1964 SEK.

[3]Annual pill users plotted in Figure 1 come from Socialstyrelsen (1984). Grouping markets into high and low pill sales (1964 SEK) relies on the SDM data (1970-74) to compute whether average HC sales per woman 15-44 was above/below the median of 5.35 SEK per woman year. Whether this grouping is defined over one particular year versus the 1970-74 period does not alter the qualitative and quantitative conclusions in Figure 1.

[4]Whether suicides are defined narrowly, using only self-inflicted injuries (ICD7 codes E970-979 and ICD8 codes E950-959), or more broadly to include accidental poisoning (ICD7:E870-E895 and ICD8:E859-E895) following the recommendation of the National Association for Suicide Prevention, the estimated correlations are similar.

[5]See Socialstyrelsen (1961-74) for abortions by age. Population data from SCB is used to express abortions per the teen

	Total HC Sales in 1000 SEK	Leading Brand Name (Market Share)	Monthly Price in SEK	(Active Substances)	Women Using Pill Annually Share	Suicides per 100,000 Teens
Year						
1966	7,840	Conluten (38.5)	4.55	(0.1 mg mestranol	9.2	3.42
1967	11,755	Conluten (28.5)	4.06	and 2 mg norethisterone)	15.5	4.23
1968	10,277	Conlunett (23.5)	3.01	(0.1 mg mestranol	18.3	5.08
1969	16,014	Conlunett (28.8)	3.02	and 1 mg norethisterone)	28.2	5.91
1970	14,948	Follinyl (27.3)	2.94	(50 mcg ethinylestradiol	26.7	4.08
1971	13,785	Follinyl (33.0)	2.94	and 500 mcg	24.6	3.74
1972	14,697	Follinyl (36.9)	3.27	norgestrel)	23.6	3.40
1973	12,986	Follinett (25.6)	3.28	(50 mcg ethinylestradiol and	20.7	7.63
1974	14,079	Follinett (31.9)	3.50	250 mcg norgestrel)	20.9	3.06

Note: Details on annual pill sales from *Swedish Drug Market*. Active ingredient from Läkemedelsverket. Suicide per 100,000 women aged 15-19 applies the narrow definition (self-inflicted injury) coinciding with ICD-7 codes E970-979 and ICD-8 codes E950-959 as reported in Socialstyrelsens individual cause of death registry, and expressed per 100,000 women aged 15-19 from SCB.

Table 1: HC Sales, Price, Hormone Content and Suicides per 100,000 Teens 1966-1974

between HC use (dash) and teen suicide (blue lines) is not readily apparent from Figure 1. After abortion is legalized in 1975, a HC subsidy is introduced. HC sales jump to a new higher level with roughly 30 percent of fecund females using HC annually. Teen suicides rise and quickly fall again. Abortion increases rapidly after 1969, as physicians exploit a regulatory loophole in the national abortion ban with increasing frequency.[6]

3 The Relationship between HC Sales and Teen Suicide

Estimates from difference-in-differences (DD) models are reported in Table 2 for both narrow definitions of suicide and broader measures that include accidental poisonings. The same above/below median HC sales per fecund female from 1970-74 categories are used to define treatment intensity in Table 2 as depicted in Figure 1.[7] Panel 1 reports coefficient estimates and robust standard errors for parsimonious DD models in levels, see columns (1) and (4).[8] Specifically, the DD model regresses suicides per 100,000 teen girls in market i during year t on a full set of market fixed effects, η_i, an indicator for years following the pill's introduction, and an interaction of the post-pill time period indicator with an indicator for

population.

[6]Empirical estimates which take into account women's access to physician staffed fertility clinics and OB-GYN care capacity to proxy for differences in the provision of abortion yield similar results to those reported here. These controls are discussed in more detail in Ragan (forthcoming).

[7]The median of the average annual HC sales per woman aged 15-44 in each market from 1970-74 is used to determine the high/low HC sales groupings; market level sales data first become available in 1970.

[8]Estimates which account for women's access to physician staffed fertility clinics and OB-GYN care capacity are similar.

Suicide per 100,000 Teens in Above/Below Median HC Sales Areas &
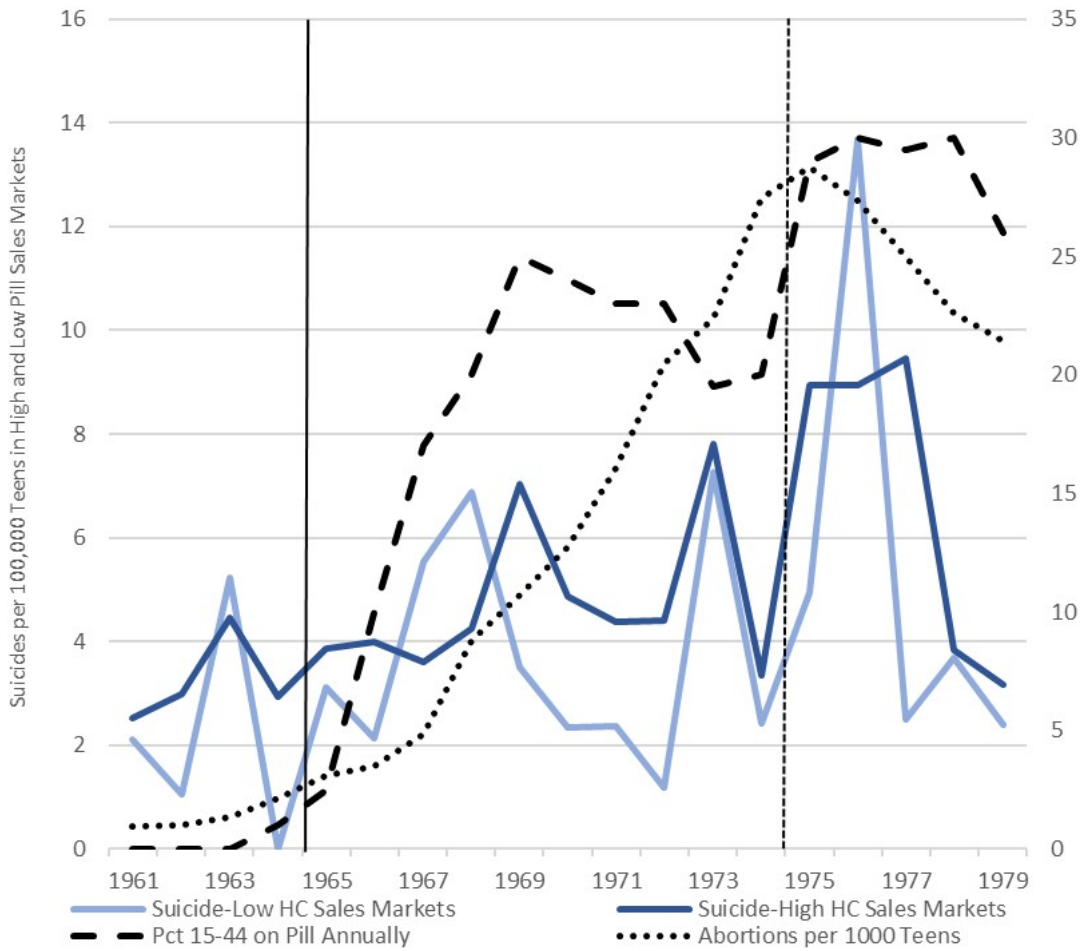Share of Women on HC Annually, and Abortions per 1000 Teens

Figure 1: Suicide Among Teens Across High and Low HC Sales Markets, HC Sales per Woman and Abortion Among Teens

above median HC sales markets:

$$TeenSuicide_{i,t} = \alpha + \beta_0 PostPill + \beta_1 HighHCXPostPill + \eta_i + \epsilon_{i,t}. \tag{1}$$

The estimation period spans 1961-1974. β_1 estimates the relative suicide mortality effect associated with residing in high HC sales market relative to teens in low HC sales market in 1965 or later, when HC is available. Both the narrow and broad suicide models yield negative coefficient estimates, though neither is significantly different from zero. Estimates of β_0 indicate that suicides among teens were more common after the pill, increasing 2.66-2.76 deaths per 100,000 teens after the pill was introduced depending on the suicide measure used.[9]

Models where HC sales per woman enter directly, replacing above median HC sales indicators, are reported in specifications (2) and (5). The estimation period spans 1961-1974, but market level sales are not reported until 1970, hence the reduced number of observations. Year and market fixed effects are included in these models. The coefficient estimates on HC sales per woman reported in panel 1 are negative in both the suicide only and broader suicide and accidental poisoning models, but not significantly different from zero.

A simulated instrument for pill sales is used to construct predicted pill sales per woman and related estimates reported in columns (3) and (6). Pill sales are imputed at the market level using the average share of sales in each market from 1970-74 to compute local sales in each year by apportioning annual sales. Imputed sales are then expressed per woman aged 15-44. The coefficient point estimates reported in panel 1 are negative, though not significantly different from zero. Large standard errors make it difficult to reject the possibility that the pill's spread was positively correlated with suicide among young women in Sweden.

A second set of specifications reported in panel 2 are similar, but express both pill use per woman and suicides per 100,000 teens in proportional terms, applying the inverse hyperbolic sine (asinh) transformation discussed in Bellmare and Wichman (2020). More specifically, the inverse hyperbolic sine of suicides per 100,000 teens in market i and year t, are regressed on HC sales or predicted sales per woman

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[9]Estimates which account for women's access to physician staffed fertility clinics and OB-GYN care capacity are similar, and abortion controls suggest access to physician staffed fertility clinics may have reduced teen suicide, as the coefficient on the number of physician staffed fertility clinics has a negative and significant coefficient when included in the DD model, though not robust to the broader definition of suicide inclusive of accidental poisoning, where the estimated effect lies just under the five percent threshold. In general the inclusion of abortion access controls do not change the reported estimates of β_1 relative to the parsimonious specification. When these controls are included in broad suicide specifications the estimates remain negative, -1.51 (1.45), but insignificant, as is also the case in the narrow suicide measure specification.

Panel 1: Suicide per 100,000 Teens in Levels

	Suicide Only			Suicide and Poisoning		
	(1)	(2)	(3)	(4)	(5)	(6)
Above Median HC Sales Market X HC Legal	-1.41			-2.17		
	(1.28)			(1.44)		
HC Legal	2.76**			2.66*		
	(1.05)			(1.12)		
Actual HC Sales per Woman		-0.37			-0.51	
		(0.54)			(0.56)	
Predicted HC Sales per Woman			-0.99			-1.36
			(2.02)			(2.25)
Market FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	Yes	No	Yes	Yes
N	980	630	910	980	630	910
R-squared	0.07	0.15	0.09	0.07	0.14	0.09

Panel 2: Suicide per 100,000 Teens Proportional (asinh)

	Suicide Only			Suicide and Poisoning		
	(1)	(2)	(3)	(4)	(5)	(6)
Above Median HC Sales Market X HC Legal	-0.02			-0.07		
	(0.14)			(0.16)		
HC Legal	0.17			0.16		
	(0.10)			(0.10)		
Actual HC Sales per Woman (asinh)		-0.22			-0.28	
		(0.38)			(0.39)	
Predicted HC Sales per Woman (asinh)			-0.48			-0.58
			(0.50)			(0.53)
Market FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	Yes	No	Yes	Yes
N	980	630	910	980	630	910
R-squared	0.16	0.27	0.18	0.16	0.25	0.18
F-statistic		10.27	8.59		11.04	8.99

Note: Robust standard errors, clustered by market, reported in parentheses. F-statistics reported in panel 2 test whether the elasticity of suicide to pill sales, or predicted pill sales, are equal to one. P-value less than 0.05 (*), 0.01 (**), or 0.001(***) are indicated.

Table 2: Estimates of the Correlation Between Pill Sales and Teen Suicide

aged 15-44 and a full set of year and market level fixed effects:

$$asinh(TeenSuicide_{i,t}) = \alpha_0 + \beta_1 asinh(HCSales_{i,t}) + \gamma_t + \eta_i + e_{i,t}. \qquad (2)$$

These proportional estimates approximate elasticities, making comparison with the medical literature easier. The estimates also confirm how negative associations estimated in levels are seen across alternative functional forms.

Estimates reported in Panel 2 are generally small, negative and imprecisely estimated. We cannot reject the null hypothesis that there is no effect of HC sales on suicide among teen girls. This is the case across all models, including the DD model, and models where direct or imputed sales per woman enter the regression. Although we cannot reject the possibility that pill sales have no effect on teen suicide, an F-statistic is reported which tests the hypothesis that the coefficient on the inverse hyperbolic sine of pill sales is equal to one. The data clearly reject this regardless of whether pill sales are measured directly or the simulated pill sales measure is used. Although the data do not allow us to reject the possibility that there is no relationship between the pill's diffusion and teen suicide, we can reject large positive associations between local treatment intensity and the incidence of suicide across markets.

4   Discussion

Estimates of the pill's influence on suicide have generated mixed results. Skovlund et al (2018) estimate that HC use is associated with a relative risk of suicide of over 3. Such an estimate would imply that if a quarter of teens adopted the pill, proportional to the average take-up suggested by the sales data I report, the teen suicide rate should have increased by fifty percent. Similarly, if the take-up rate was greater, proportional to half of teens as estimated by Socialstyrelsen (1984), the suicide rate among teens should have doubled. Doubling exposure to HC, or HC sales in my model, does not lead to a doubling of the occurrence of suicide among teens. All of the elasticity estimates reported in Table 2 would reject a null of a suicide elasticity of unity.

Better understanding whether the incompatibility of these estimates is due to the definition of the control groups, never-users by choice or by national policy design, or the very different institutional settings in which women resided, in particular as pertains to abortion rights, is an avenue for future research. Using a natural experiment design, in the form of the introduction of the birth control pill in Sweden, to estimate the relationship or elasticity between market level HC sales exposure and suicides and accidental poisonings among teens may be a promising avenue for future research. The novel HC sales data and market level counts of suicide per teen do not suggest that the spread of HC after approval

for use late in 1964 led to a significant increase in suicides among teenage girls. Future work could more fully exploit individual variation in exposure to estimate a hazard model where local HC sales would be the treatment variable. This may allow for a more precise understanding of how local exposure to HC influences suicide among young women and whether teens are particularly sensitive to local HC use relative to the general population. Such models could also be used to explore whether estimates differ with the legalization of abortion and other important fertility control innovations.

The rich data on HC sales at the market level could be combined with health data along many margins to understand how the pill altered maternal mortality, child mortality, or other dimensions of maternal and child health. Likewise, the historical nature of the natural experiment I study allows a means of quantifying long run health outcomes. Applications to teen suicide and the aggregate analysis presented here are but one margin and approach for using HC sales data to better understand the pill's impact on women's lives.

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