

## Unwanted Teenage Pregnancies: Sociological Model Based on Agents

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### *Abstract*

This study used new methodologies embedded in agent-based modeling to generate specific characteristic phenomena and core dynamics in unwanted teenage pregnancies. A NetLogo software was used to simulate data exhibiting the pattern of unwanted teenage pregnancy. The simulation revealed four agents contributing to the number of unwanted pregnancies: number of multiple partners, commitment, birth control method/s used and frequency of sex education. Among the four agents, the number of sexual partners significantly influenced the rate of unwanted pregnancies. However, commitment was not observed to be a contributory factor for the number of unwanted teenage pregnancies; rather it was more sensitive to the interactions among different agents. The Multiple Linear Regression model was generated from the interactions of the four predictor-variables and it illustrated prediction of unwanted teenage pregnancies in a given community.

Keywords and phrases: Agent-based modeling, birth control methods, commitment, multiple sexual partners, NetLogo

### *Introduction*

The truth is appalling: sexual activities are increasing among teenagers. It is noted that a proportion of women aged 15–24 who are sexually experienced has increased from 25% in 1998 to 32% in 2008 (Finer & Hussain, 2013). These practices increase the risk of having unplanned pregnancies among the youth. Among first-time mothers, the proportion who were teenagers increased from 20% in 2000 to 27% in 2010 (Finer & Hussain). Furthermore, the same study showed that poor, rural and young women who have unplanned pregnancies are likely to seek abortions under unsafe conditions. The Philippines is not exempted from this observation, as it is among the top 10 countries with escalating population of teenage mothers and with 64,000 abortions annually (World Bank, 2010). Unsafe abortion

carries significant risks for Filipino women: about 1,000 die each year from abortion complications contributing to the nation's high maternal mortality ratio. This abortion is due to one obvious reason: unwanted pregnancies among young women.

In light of this reality, different authors have explained the various factors that have increased the rate of unwanted pregnancies. Some of the factors include an incorrect use of effective contraceptive methods, multiple sexual partners and unprotected sex (CDC, 2015; Finer & Hussain, 2013). Various solutions were presented in addressing this pressing problem, including evidence-based programs on the use of contraceptives (Wang, Long, Cai, Wu, Xu, Shu, Li, Wei, Zhang, Xiong & Yin 2015,

Sonfield et al., 2004 ); delaying sexual debut and reduction of number of sexual partner (Baumgartner, Geary, Tucker, & Wedderburn, 2009) and information dissemination campaigns (Wang et al., 2015).

The data gathered have revealed substantial variables and contemporary solutions to explain the increasing rate of unwanted teenage pregnancies. However, there is no study that encapsulates and emulates the interactions of behaviors of various individuals in a given system. There are also few studies that identify system variables that integrate the set of equations relating to these variables. Attempting to conduct experimental trial through simulation of data using recognized software is an interesting unconventional research to do.

The gaps can be addressed by using an agent-based model to generate familiar but enigmatic global patterns. Through NetLogo, researchers were able to explore emergent phenomenon using simulation without actual data. The software can display complex systems in the form of models, making it possible to manipulate various variables similar to the model used. Also, the use of this software allows researchers to explore different connections between the micro-level behavior of individuals and the macro-level pattern that emerge from the interactions of different variables. The utilization of NetLogo has generated specific characteristic phenomena and core dynamics in unwanted pregnancies.

The study is further bordered by the following delimitations: that the results are based on computer simulated data, not actual data that the sexual interaction is limited to woman to man relations, and that the infection tendency is limited to the fertility (whether positive or negative) of teen age women. Also, the study is concentrated othe variables identnified, namely sexual partners, commitment, birth control methods and sex education.

### *The Model*

The paper is anchored on the NetLogo AIDS model of Wilensky (1997). The model simulates the spread of human immunodeficiency virus (HIV), via sexual transmission in a small isolated human population. It illustrates the effects of certain sexual practices across a population. The model examines the emergent effects of four aspects of sexual behavior. It includes the population's tendency to practice abstinence, the amount of time an average "couple" in the population will stay together, the population's tendency to use condoms and the population's tendency to get tested for HIV (Wilensky, 1999). The exploration of the first and second variables illustrates how changes in sexual mores in a society contributes to the increase in the prevalence of sexually transmitted diseases, while exploration of the third and fourth may provide contemporary solutions to the problem.

In application, the AIDS model can simulate the possible increase of unwanted pregnancy since all parameters are similar to that of the original model. A summary of the parallel concepts of AIDS and unwanted pregnancies are stipulated below:

AIDS MODEL	UNWANTED PREGNANCY MODEL
1. HIV (+) INFECTED (-) NOT INFECTED (?) UNDEFINED	1. (+) UNWANTED PREGNANCY (-) NOT PREGNANT (?) UNDEFINED
2. No. of people	2. No. of people
3. Average coupling tendency	3. Number of sexual partners
4. Average commitment (weeks)	4. Average commitment (weeks)
5. Average condom use	5. Use of birth control methods
6. Frequency of testing (per year)	6. Frequency of sex education (per year)

The identification of similarities from the two models has established the formulation of different parameters and assumption based on the nature of unwanted teenage pregnancies. The Unwanted Pregnancy Model contains the following major parameters, namely the number of people in a given community, average number of sexual partners, average commitment, average birth control methods

and frequency of sex education. Formulation of assumptions were based on the said parameters where the number of unwanted pregnancy decreases when average partner decreases, commitment increases, increased usage of birth control methods, and more attendance to sex education.

Specifically, the applied parameters are defined as follows:

- Number of sexual partners: the number of person/s an individual has had sexual relations with.
- Average commitment in weeks: the mean duration an individual spends exclusively with a sexual partner which is counted in weeks.
- Use of birth control methods: the tendency of the individual to use birth control per sexual interaction which is scored in a scale of one to ten.
- Frequency of sex education: the number of sex education classes the individual attends per year

With the given parameters the following assumptions were formulated: that the greater the number of sexual partners, the more likely one becomes pregnant; that the longer exclusivity of time spent per sexual partner, the less likely one becomes pregnant; that the greater the number of birth control methods used, the less likely one becomes pregnant; and that more attendance to sex education, the less likely to get pregnant.

An agent is therefore defined as a computational objects modeled as interacting according to rules over space and time, not real people. The rules are formulated to model behavior and social interactions based on information or data sets. Hence, agents are considered as micro-behaviors. It is further believe that the interactions of these micro-behaviors will become a macro level phenomenon explaining the incidence of unwanted teenage pregnancies.

The interactions of agents used in the

study are shown in Figure 1. The circles are the identified agent variables using the different parameters stipulated above. With these variables, individual characteristics and behavior in unwanted pregnancies can be observed and predicted.

### Objectives

The main objective of the study was to create a sociological model for unwanted pregnancies based on agents. Specifically, it determined the variables (agents) affecting incidence of unwanted pregnancies, analyzed the different interaction of variables, and generated a model using the agents for unwanted pregnancies.

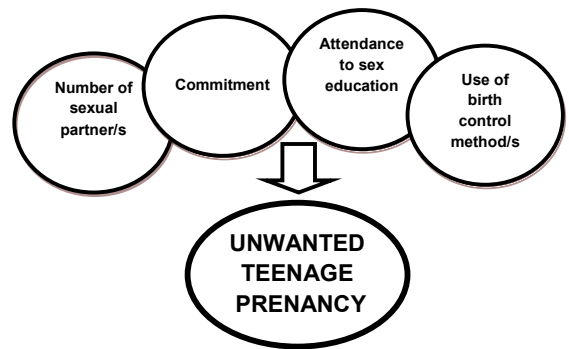


Figure 1. Identified agent variables using different parameters.

### Methodology

This is a descriptive research that employed agent-based modeling using NetLogo software. NetLogo is a multi-agent programmable modeling environment that explores the connection between the micro-level behavior of individuals and the macro-level patterns that emerge from its interaction. It comes with different models with pre-written simulations that can be readily used and modified. Among the different models, it was the AIDS model of Wilensky that shows similar behavior and characteristics of factors affecting unwanted teenage pregnancies.

The AIDS Model examines the emergent effects of the four aspects of sexual behavior. The modified version of the model allows the

user to control the population's tendency to practice abstinence, the amount of time an average couple in the population will stay together, the population's tendency to use birth control methods, and the population's tendency to get sex education. Exploration of the first and second variables illustrate how changes in sexual mores in our society have contributed to increases in the prevalence of unwanted teenage pregnancy, while exploration of the third and fourth may provide contemporary solutions to the problem.

After identifying the variables, actual simulation of the data commenced using the NetLogo program. The simulated data were run ten times to mimic the actual scenario in the community and until the outcomes showed a pattern. The simulations were conducted following the prescribed parameters based on literature/studies and were set-up according to the average set by the model itself.

In detail, the parameters were set as follows: the population was set at 500 individuals. For the number of sexual partners (parameter 1), it was based on the survey conducted by MORE magazine in 2008. The survey shows that an average 21-year-old woman has nine sexual partners compared with seven for men in European countries (Patterson, 2012). While parameter 2, was presumed that an average individual was likely to stay in a couple for 100 weeks. In this parameter, the tendencies of both individuals in a relationship were considered. The parameter 3, on the other hand, was based on a study revealing that one in five sexually active female teens (20%) and one third of sexually active male teens (34%) reported having used both the condom and hormonal method the last time they had sex (Guttmacher Institute, 2015). Based on the data, the average birth control method used was set at two methods per individual. While in parameter 4 it determined the average frequency of an individual to get sex education in a one-year time span. Set at 1.0, the average person may get sex education to prevent unwanted pregnancies once a year. Moreover, in determining the low

and high values, the 25th and the 75th percentile of the average values were used respectively, in a span of 260 weeks or 5 years (iterations).

The "simulated" outcomes were then recorded and tabulated. The results of the simulations were analyzed using ANOVA: General Linear Model to determine the statistical relationships between agents. Multiple regression analysis was also used to determine the model that would account for the variability in unwanted pregnancies considering the agents having significant relationships.

## *Results and Discussions*

### *The variables of unwanted pregnancies*

The identified variables similar to the AIDS Model are the number of multiple partners, commitment, birth control method used, and frequency of sex education. Tabular value shows that the number of unwanted pregnancies is contributed by the identified agents. The data revealed that the rate of unwanted pregnancies is 9.71% increased when there is a high number of sexual partners, low level of commitment, low use of birth control method, and low frequency of sex education. This data is confirmed by the studies of Reis et al. (2011) reporting that sex education encourages students to postpone sex until they are older, and promotes safer-sex practices among those who choose to be sexually active by using contraception among sexually active youth. A national study conducted by Mueller, Gavin and Kulkarni (2008) found that sexually active adolescents who received sex education at school were more likely to use birth control at first and to have fewer unwanted pregnancies. Kirby, Laris and Roller (2007) summarized evaluations of school-based sexuality and HIV education programs covering both abstinence and contraception and concluded that some of these programs can delay the onset of intercourse, reduce the frequency of intercourse, decrease the number of partners, and increase condom use. In addition, Baumgartner et al. (2009) observed that adolescents who have delayed sexual debut and those with reduced number

of sexual partners were less likely to have unintended pregnancies.

Moreover, it revealed that the prevalence of unwanted pregnancy is only 3.22% when the number of sexual partners decreases, when there is a little commitment, when there is a high use of birth control methods, and when the frequency of sex education is high. It is observed that of the four agents, the level of commitment is not sensitive to the rate of unwanted pregnancies. Therefore, individual commitment does not contribute to the probability of unwanted pregnancies in a given community.

Table 1. Simulation Results of the Three Factors Affecting the Rate of Unwanted Pregnancy, Dichotomized as Low and High.

		FACTOR A Multiple Sexual Partners								
		HIGH				LOW				
		HIGH		LOW		HIGH		LOW		
FACTOR C	LOW	HIGH	5	4.8	7.6	11.2	4.4	4.6	4.8	4.5
			5.4	4	10.1	7.2	3.8	4.2	4.2	5.4
			4.6	5.4	15.2	9.6	4.4	3.8	4.6	3.8
		LOW	4.4	5.8	10.2	8.2	4.2	4.6	4	5.4
			4.8	5.6	9.2	8.6	3.8	4.2	4.6	3.8
			4.4	4.2	5.8	5	3.2	3.2	3	3.4
	HIGH	4.6	4.2	5.4	5.8	3.8	2.6	4.6	3.8	
		4.8	5	3.8	4.4	3.4	3.2	3.4	4.0	
		5	4.4	5	5.4	3.4	3.6	3.4	4.4	
		4.4	4.6	5.4	4.8	3.4	3.2	4.6	4.0	
		LOW	5.4	5.6	8.4	6.6	3.8	3.6	7.4	5.8
			5.2	5	9.4	6.6	3.4	3	5	6.2
5	5.2		8.8	6.4	3.8	3.6	6.6	5		
4.6	4.4		6.4	6.2	3.4	4	5.6	4.8		
4.8	4.8		8.8	6.6	3.6	3.8	5.4	5.8		
3.6	4.2		3.8	4.4	3.6	3	3.2	3.2		
HIGH	4	4.2	3.4	5	3.6	3.4	3	3		
	4	4.2	4	4.6	3.2	3.6	4	3.2		
	4.4	4	4.4	4.6	3	2.6	3	3.2		
	3.8	4	4	4.2	3.2	3.2	3.2	3.2		
	FACTOR D									

The analysis of the different interaction of variables

Table 2 illustrates the level of significance among factors with regards to its contribution to unwanted pregnancies. As seen in the table, there were 13 out of 15 independent variables significantly correlated with the dependent variable. The probability is less than the set alpha of 0.05. Data show that most of the factors are substantial in explaining the number of unwanted pregnancies, except Factor B: Commitment and interaction of Factor B and D. This finding is consistent with the previous data showing Factor B: Commitment is not a contributory factor to the increase of unwanted

pregnancies; rather it is more sensitive to the interactions among different factors. This is based on the assumption that an increased level of commitment entails lesser sexual partners and high use of birth control methods, but not necessarily a valuable tool in decreasing the number of unwanted pregnancies per se. Guerero, Andersen, and Affi (2014) confirm this data with their observation that people in highly committed relationships are more willing to make sacrifices for each other, resulting in less possibility of infidelity.

Moreover, data show the first three factors having high F value are Factor A: multiple sexual partners, Interaction between factors A & B and Interaction between factors A & D, showing high influence in the number of unwanted pregnancies. The results further revealed that the common variable observed among the three identified factors is the number of multiple sexual partners. This means that multiple partners greatly influence the rate of unwanted pregnancies.

In addition, Factor A represents the highest F value of 211.91. This denotes that the parameter, multiple sexual partners, is the main predictor among variables in determining the rate of unwanted pregnancies. However, in a study conducted by Mueller et al. (2008), it revealed that sharing information with young people about sexuality, contraception, and other aspects of reproductive health does not increase sexual activity. Moreover, the study shows that sharing information and helping young people think about their future help to delay the start of sexual activity, increase contraceptive use by those already sexually active, lower the number of sexual partners, and decrease the frequency of sex. This is further supported by Kohler, Manhart and Lafferty (2008) that an adolescent who received comprehensive sex education had lower risk of pregnancy than an adolescent who received abstinence-only or no sex education. It can be surmised that Factor A is effective if other factors are applied and used in combination with this variable.

Table 2. ANOVA: General Linear Model of Unwanted Pregnancy versus Factor A, Factor B, and Factor C

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Factor A	1	110.224	129.032	129.032	211.91	0.000
Factor B	1	76.452	1.2	1.2	1.97	0.162
Factor C	1	8.742	6.385	6.385	10.49	0.001
Factor D	1	117.306	2.964	2.964	4.87	0.029
AB	1	13.689	44.944	44.944	73.81	0.000
AC	1	7.744	29.241	29.241	48.02	0.000
AD	1	13.689	37.249	37.249	61.17	0.000
BC	1	1.482	6.972	6.972	11.45	0.001
BD	1	45.582	0.012	0.012	0.02	0.887
CD	1	0.09	7.832	7.832	12.86	0.000
ABC	1	8.649	19.8	19.8	32.52	0.000
BCD	1	0.042	6.328	6.328	10.39	0.002
CDA	1	3.025	12.96	12.96	21.29	0.000
DAB	1	11.664	22.898	22.898	37.61	0.000
ABCD	1	11.236	11.236	11.236	18.45	0.000
Error	144	87.682	87.682	0.609		
Total	159	517.3				

Legend:  
 Factor A: Number of multiple sexual partners  
 Factor B: Average commitment in weeks  
 Factor C: Number of birth control methods used  
 Factor D: Frequency of sex education  
 AB: Interaction between Factor A & Factor B  
 AC: Interaction between Factor A & Factor C  
 AD: Interaction between Factor A & Factor D  
 BC: Interaction between Factor B & Factor C  
 BD: Interaction between Factor B & Factor D  
 CD: Interaction between Factor C & Factor D  
 ABC: Interaction between Factors A, B & C  
 BCD: Interaction between Factors B, C & D  
 ACD: Interaction between Factors A, C & D  
 ABD: Interaction between Factors A, B & D  
 ABCD: Interaction between Factors A, B, C & D

*The unwanted teenage pregnancy model*

Using multiple regression analysis, different factors bearing significant P values (as seen in Table 2) were analyzed to create a model. The identified factors were the independent variables that were used to explain the rate of unwanted teenage pregnancies. Table 3 shows the multiple regression analysis with the model:

$$\text{Unwanted pregnancy.} = 4.39 + 5.32 \text{ Factor A} + 1.38 \text{ Factor C} - 0.805 \text{ Factor D} - 4.73 \text{ AB} - 3.67 \text{ AC} - 3.82 \text{ AD} - 2.16 \text{ BC} - 1.74 \text{ CD} + 4.47 \text{ ABC} + 2.18 \text{ BCD} + 3.19 \text{ CDA} + 4.21 \text{ DAB} - 4.17 \text{ ABCD}$$

Unwanted pregnancy is, therefore, the sum of the complex interaction of three variables namely multiple sexual partners, birth control method used, and frequency of sex education. On the other hand, the level of commitment indirectly affects the whole phenomenon (unwanted pregnancies) but greatly influences the interactions of other factors contributing to the rate of unwanted pregnancies. Specifically, it is observed that multiple sexual partners and birth control method used are directly

proportional to the increase of unwanted pregnancies; while, the frequency of sex education is inversely proportional to the rate of unwanted pregnancies.

The model also suggests that the variability of the predictor variables (multiple sexual partners, commitment, and use of birth control method and sex education) has explained 81.0% (R-Sq adj) of the variation in unwanted pregnancies. The remaining 19.0% are unknown variables in the study. The positive coefficient implies a direct relationship, while negative coefficient suggests an inverse relationship between variables.

The positive coefficient of the factors: multiple sexual partners and birth control method used, shows that when the variation in this factor increases, the variability in the number of unwanted pregnancies increases. This implies that the said factors have an impact on the increased probability of unwanted pregnancies. The result also suggests that there is a need to minimize the occurrence of the two factors to reduce unwanted pregnancies.

Moreover, negative coefficient of the Factor D: frequency of sex education, implies that the increase in the number of sex education decreases the chances of unwanted pregnancies. On the other hand, when the number of sex education decreases, the variability of unwanted pregnancies increases. This is true because increasing the frequency of sex education would result in the postponement of sex or promotion of safer-sex practices among young individuals.

The finding is aligned with a study conducted at and integrated into all levels and subjects of schooling, boasts one of the lowest teen birth rates in the world — 5.1 per 1,000 women aged 15–19 — a rate six times lower than that of the U.S. (Berne & Huberman, 1999; United Nations, 2012). Likewise, in Germany, where sex education is comprehensive and targeted to meet the reading and developmental needs of the students, the teenage birth rate is three and a half times lower than that of the

U.S.; its teenage abortion rate is about four and a half times lower; and its HIV prevalence rate is three and a half times lower (Destatis, 2013; Kost & Henshaw, 2012; UNAIDS, 2012; United Nations, 2012).

In a similar study conducted by Kirby (2007), it was observed that sex education leads to a 40 percent delay in sexual initiation, reduction in the number of sexual partners, or increase in condom or contraceptive use. Also, the same study revealed 30 percent reduction on the frequency of sex, including a return to abstinence and 60 percent reduction of unprotected sex (Kirby, 2007). The various studies support the findings that sex education is one important approach in dealing with the number of unwanted pregnancies.

Moreover, Kirby, Laris and Rolleri (2007) summarized the evaluations of school-based sexuality and HIV education programs covering both abstinence and contraception and concluded that different programs can delay the onset of intercourse, reduce the frequency of intercourse, decrease the number of partners, and increase condom use. The different studies support the created model, showing that there is no distinct variable that can explain the incidence of unwanted pregnancies. Rather, an unwanted teenage pregnancy is a result of the interaction of the four variables.

Table 3. *Multiple Regression Analysis: Regression Analysis: Unwanted Pregnancies versus Factor A, Factor B*

Predictor	Coef	SE Coef	T	P
Constant	4.385	0.176	24.91	0.0000
Factor A	5.325	0.3048	17.47	0.0000
Factor C	1.375	0.3048	4.51	0.0000
Factor D	-0.805	0.2489	-3.23	0.0020
AB	-4.73	0.352	-13.44	0.0000
AC	-3.665	0.4657	-7.87	0.0000
AD	-3.825	0.4311	-8.87	0.0000
BC	-2.16	0.352	-6.14	0.0000
CD	-1.735	0.4311	-4.02	0.0000
ABC	4.47	0.6097	7.33	0.0000
BCD	2.18	0.4978	4.38	0.0000
CDA	3.185	0.6585	4.84	0.0000
DAB	4.21	0.4978	8.46	0.0000
ABCD	-4.17	0.8622	-4.84	0.0000

S = 0.7871

R-Sq = 82.5%

R-Sq(adj) = 81%

## Conclusion

The prevalence of unwanted pregnancies can be explained by the interactions of the following factors: multiple sexual partners, birth control method used, and frequency of sex education. The formulated mathematical model can be used to determine the rate of unwanted pregnancy in a given community. Among the factors, multiple sexual partners have the biggest impact on the rate of unwanted pregnancies. Commitment is another factor that has no bearing on the number of unwanted pregnancies but has an impact on the interactions among different factors.

## Recommendations

The study is recommended to the Commission on Population (POPCOM) to use the mathematical model in computing the number of unwanted pregnancies in a given community. Also, it is recommended to the Department of Health to consider the four variables (multiple sexual partners, birth control method, used commitment, and frequency of sex education) in making programs related to decreasing teenage pregnancies. The Local Government Unit can also use the results of the study as basis for making policies that will decrease the number of unwanted teenage pregnancies. Lastly, it is recommended to other researchers to utilize the model using actual data to validate the model.

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