科技部補助專題研究計畫成果報告
期末報告

HIV/AIDS的移動迷宮：關於你的秘密!(I)

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計 畫 編 號 ： MOST 104-2633-E-040-001-
執 行 期 間 ： 104年08月01日至105年07月31日
執 行 單 位 ： 中山醫學大學醫學資訊學系

計 畫 主 持 人 ： 張啟昌

報 告 附 件 ： 出席國際學術會議心得報告

中 華 民 國 105 年 10 月 25 日

中 文 摘 要 ： 本計畫以行為作業管理(BOM)觀點：研究男性大學生全程使用保險套的動機，進一步分析實施衛教干預後會產生何種使用保險套行為的改變。

全程使用男性保險套已經被證明可以有效避免在性行為中得到人類免疫缺陷病毒(HIV)和性傳染病。台灣從1984到2014年已累積29,475名HIV感染案例，其中在感染案例中，20-39歲所佔比例高達73.43%。許多研究指出，在大學階段可能會因為無保護的性行為而發生感染。雖然全程使用保險套是預防HIV和性傳染病最有效的方法，但是目前大學生使用保險套的比例仍然偏低。

從實務問題出發，本研究採用演化博弈理論(Evolutionary Game Theory , EGT)模式化男性大學生全程使用保險套的行為決策。雖然傳統博弈理論對於不同群體的行為可以經過時間達到均衡，但是須面對結果未必是穩定或實務可行。演化博弈理論的價值在於可以超越傳統博弈的假設，並提供本研究在沒有理性假設、具備相互學習、解釋衛教干預的脈絡以及衝突解決的特色，充分發揮模擬流行病學中傳染動態的優點。

研究設計考慮每位男性大學生在從事性行為時有下列二擇一的行為策略：「高意願的全程使用男性保險套」或「低意願的全程使用男性保險套」，進而觀察兩群體策略演化的過程。至於衛教干預則是建構在「增加(相對)收益」與「降低(相對)成本」二維平面所形成四個區域象限，並透過2x2的博弈報酬矩陣(payoff matrix)觀察個別參數機率值的變化，深入剖析使用保險套的動機是屬於：搭便車(free riding)、利他主義(altruism)或西瓜效應(bandwagoning)；並加以理解(i)會有哪些因素決定全程使用男性保險套行為的動機；(ii)這些因素是如何影響全程使用男性保險套行為的結果；最後完成(iii)演化博弈理論的典範移轉以及提供多元情境因果關係的解釋。

中 文 關 鍵 詞 ： 男性保險套; 人類免疫缺陷病毒; 演化博弈理論; 傳染動態

英 文 摘 要 ： This proposal studies the impact of inconsistent use of male condoms on the ineffectiveness in interventions to improve the rate of college students’ condom use during sex.

Globally, the overall growth of the epidemic has stabilized in recent years. However, almost 78 million people have been infected with the HIV virus and about 39 million people have died of HIV at the end of 2013. According to the statistics of Taiwan ‘s Centers for Disease Control, the first case of HIV was diagnosed and reported in 1984. As of November 2014, a cumulative 29,475 cases of HIV infection were reported in Taiwan. HIV/AIDS in Taiwan has been increasing at a rate of 17% annually since 1984. Almost 40 percent of HIV/AIDS cases in Taiwan occur in the age range of 20 to 29 years old. Many of the reported cases are in the college-age years and infection might have occurred through unprotected sex behaviors during their college years, however, the condom using compliance rate is generally low.

This study uses evolutionary game theory (EGT) to model college students' condom using strategic decisions. Given a policy, it takes time for group behavior to converge to an equilibrium, which may not necessarily be stable or even desirable. Therefore, our approach using the evolutionary game has merits, as it implicitly accounts for the process of merging diversities, resolving conflicts through learning, and adjusting strategies among the college students.

As a baseline, it is assumed that every college student has two condom using strategies: either condom using with High or Low compliance. The equilibrium obtained from EGT can indicate the percentage of the cohort that practices High and Low compliances. The equilibrium can also be interpreted as the probability that each male plays a mixed condom using strategy. The equilibrium indicates three motivations: free riding, altruism and bandwagoning. These motivations are designed to investigate (i) which factors have influence on the condom using decision, (ii) how the factors affect the behavior decision, and (iii) which kinds of scenarios in practice correspond to the conditions in each the equilibrium.

英文關鍵詞： Male Condoms; Human Immunodeficiency Virus (HIV); Evolutionary Game Theory; Transmission Dynamics

科技部補助專題研究計畫成果報告

（□期中進度報告/■期末報告）

（計畫名稱）

計畫類別：■個別型計畫　□整合型計畫
計畫編號：MOST　104-2633-E-040 -001 -
執行期間：104 年 8 月 1 日至 105 年 7 月 31 日

執行機構及系所：中山醫學大學醫學資訊學系

計畫主持人：張啟昌

本計畫除繳交成果報告外，另含下列出國報告，共 _1_ 份：
□執行國際合作與移地研究心得報告
■出席國際學術會議心得報告
□出國參訪及考察心得報告

中　華　民　國 105 年 10 月 25 日

科技部補助專題研究計畫成果自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現（簡要敘述成果是否具有政策應用參考價值及具影響公共利益之重大發現）或其他有關價值等，作一綜合評估。

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說明：

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3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性，以 500 字為限）。

Our solution approach overcomes the shortcomings of traditional epidemiological modeling by formulating strategic males using an evolutionary game embedded in a transmission dynamics model. Our model indicated there are three possible equilibria: zero compliance, partial compliance, and full compliance among all males, through which we are able to explain “why don’t interventions work as expected?”

4. 主要發現

本研究具有政策應用參考價值： ■否 □是，建議提供機關________

(勾選「是」者，請列舉建議可提供施政參考之業務主管機關)

本研究具影響公共利益之重大發現：■否 □是

說明：(以 150 字為限)

If the bandwagoning motivation is managed properly, it can lead to full compliance, otherwise nil.

1 Introduction

Consistent use of male condoms has been shown to be an effective way to prevent human immunodeficiency virus (HIV) and other sexually transmitted diseases (STDs) among sexual active individuals (U.S.A. CDC, 2014). Globally, the overall growth of the epidemic has stabilized in recent years. However, almost 78 million people have been infected with the HIV virus and about 39 million people have died of HIV at the end of 2013. Today, almost 5 million people are living with HIV in South, East and South-East Asia (WHO, 2015). According to the statistics of Taiwan's Centers for Disease Control, the first case of HIV was diagnosed and reported in 1984. As of November 2014, a cumulative 29,475 cases of HIV infection were reported in Taiwan. HIV/AIDS in Taiwan has been increasing at a rate of 17% annually since 1984 (Taiwan CDC, 2014). The development of successful interventions to prevent the spread of HIV/AIDS will contribute to reach these goals. Behavioral interventions seek to reduce the risk of HIV infection by addressing risky behaviors or activities. To date, the groups most at risk of becoming infected – *college students population* – are all too often being neglected. Research examining condom use among Taiwanese college students found that while 55-63% reported having more than two sexual partners during their lifetime, only 12-25% consistently used condoms (Chen, 2003; Tung, 2008; Tung et al., 2012). To combat HIV/AIDS epidemic, Taiwan’s CDC has invested resources in interventions to increase the consistent and correct use of condoms during sex. However, the effect of the interventions varies.

There is a group of studies begin to focus on condom using and use behavioral theory (e.g. theory of planned behavior) to explain their low compliance (Ajzen and Fishbein, 1980; Janz and Becker, 1984; Grimley and Lee, 1997; Prochaska et al., 2002; Gullette and Turner, 2004; Lin et al., 2007; Tung et al., 2009). In these studies, factors, such as the importance of the consistent and correct use of condoms during sex, the level of social pressure among college students’ condom using compliance, and the level of convenience to access the condoms are contributed to the intention of the college student. Although the overall condom using compliance is low, studies find that college students to use a condom with high compliance in some situations, but with low compliance in the other situations (Redding and Rossi, 1999). Besides, college students tend to learn from the others, therefore, change their condom using compliance over time (Chen and Yen, 2005). Without understanding college students’ decision-making on the condom using, motivations, and the learning process, there will be a poor estimation of condom using performance and inappropriate interventions designed by the health providers to improve the compliance. To counteract the adverse effects of uncertain effect of interventions, formality and discretion of interventions need to be taken into consideration (Naveh, 2007). However, there is a lack of systematic way for the health providers to modify the interventions to fit their own settings. The objective of this year is to help the health providers make a proper decision about condom using intervention(s) to help college students via studying college students’ condom using behavior.

2 Relevant Literatures

Our work is closely related to two distinctive streams of literature: behavioral operations management (BOM) literature and epidemiology literature. We contribute to the former by extending the literature on the random yield and supply disruption models in BOM to a strategic operator setting. We contribute to the latter by formulating a theoretical model of transmission dynamics that incorporates condom using strategy.

The existing work on yield uncertainty primarily incorporates supply disruptions into classical inventory or capacity models and discusses risk management tools to reduce the vulnerability of the operating system or supply chain, see Tomlin and Wang (2012) for a comprehensive review. By developing a Cournot model of endogenous entry, Deo and Corbett (2009) show that yield uncertainty can result in the high concentration of the U.S. flu vaccine market and contribute to a reduction in the industry output. In the presence of strategic consumer behavior (i.e., consumption externality in economic studies, see Dana and Petruzzi, 2001; Su and Zhang, 2008; Swinney, 2011), Arifoglu et al. (2012) investigate the impact of yield uncertainty on the inefficiency in the influenza vaccine supply chain. Most papers in this stream assume that the yield or supply uncertainty is exogenously specified. To our knowledge, our proposal is the first to consider an operating system with supply externality, i.e., operators’ (college students’) decision for their operational behavior (high or low condom using compliance rate) that is influenced by the interactions with other operators.

Although there is extensive work in the epidemiology literature on condom using issues (e.g., Austin et al. 1999, Cooper et al. 1999, McBryde et al. 2007), only a few papers on epidemiological models incorporate adaptive human behavior to predict the infection level and claim the predictions to be more accurate (Bauch 2005, d’Onofrio et al. 2007, Funk et al. 2009, Kiss et al. 2010). As mentioned previously, there is a relationship between condom using compliance and HIV/STDs prevalence level; therefore, it is essential to consider college students' condom using strategy. Empirical evidence suggests that college students' to use a condom decisions may depend on several factors. Besides, several studies including Tung et al. (2009), MacPhail et al. (2002), and Bandura (1997) point out that peer influence could be a factor as well. Unlike our approach, the existing model-based studies on epidemiology do not explicitly incorporate intervention strategic behavior into the transmission dynamic models in the setting within a university campus.

3 Model

In this section, we describe various components of our model that integrates the classic transmission dynamics within a university campus with the evolution of the proportion of consistent use of male condoms in evolutionary game theory.

3.1 Epidemiology model: Transmission dynamics

Modeling transmission dynamics is an important step to understand how human immunodeficiency virus (HIV) spread. Ross and MacDonald develop a host-vector-host model to depict the transmission of malaria in open space (Ross, 1911; MacDonald, 1957). Their models assume that the transmission among hosts is indirect via the vector-mosquito. The vector carries a problematic pathogen transiently whereas the host is infectious for a longer period. We can apply the Ross-MacDonald model to describe transmission dynamics in our model setting. Our transmission dynamics model is given in Figure 1.

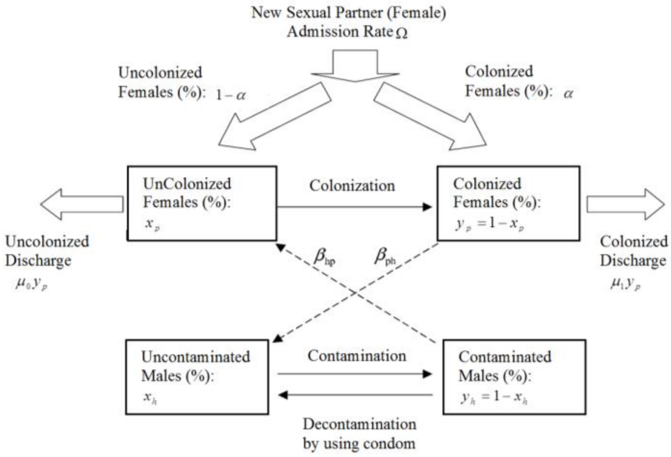


Figure 1 Transmission dynamic model

In this model, two roles are involved and there are two statuses for each role: female and male. A female can be either colonized or uncolonized with HIV; whereas a male is either contaminated or not. After every sex behavior between each other, both of them might change their status. For instance, if an uncontaminated male has contact with a colonized female who carries HIV, there is a chance that the pathogens will be passed onto male. Therefore, the status of the male changes from uncontaminated to contaminated following a certain rate. If the male has consistent and correct use of the male condom, the pathogens could be free from HIV infection. However, if the male does not use of the male condom before sex behavior with an uncolonized female, the status of uncolonized female will change to colonized with a certain rate. In Figure 1, we use the notations x_p and y_p to denote the percentages of uncolonized females and colonized females with the subscript p for females. Likewise, x_h and y_h represent the percentages of uncontaminated males and contaminated males, respectively, where the subscript h stands for male. Let the frequency of coitus per week be denoted by Ω. Since an individual may carry HIV for a long time without knowing it, among the females, a percentage α of them is assumed to be carrying and $(1-\alpha)$ of them uncolonized. That is, $\Omega = \mu_0 x_p + \mu_1 y_p$, where μ_0 and μ_1 are discharge rates of uncolonized and colonized females, respectively. The following differential equations describe the process of HIV transmission in Figure 1.

$$\dot{x}_p = (1-\alpha)\Omega - \beta_{hp} x_p y_p - \mu_0 x_p \quad (1)$$

$$\dot{y}_p = \alpha\Omega + \beta_{hp} x_p y_h - \mu_1 y_p \quad (2)$$

$$\dot{x}_h = -\beta_{hp} x_h y_p + \eta y_h \quad (3)$$

$$\dot{y}_h = \beta_{hp} x_p y_p + \eta y_h \tag{4}$$

where β_{hp} is the transmission rate from contaminated male to uncolonized female β_{ph} is the transmission rate from colonized female to uncontaminated males; and η is the decontaminated rate. The above transmission dynamic equations are straightforward. For instance, the change rate for uncolonized female $\dot{x}_p (dx_p / dt)$ in (1) is equal to the frequency of coitus of new HIV-free females, less the rate of females who get the infectious pathogens from contaminated males and the discharge rate of uncolonized females. It can be seen that the right-hand-sides of (1) - (4) sum up to zero, reflecting the system is in balance at all times.

One important parameter to measure the infectious HIV transmission is called the reproduction number *R*, which is defined as the average number of secondary infected (or colonized) females caused by a primary case. It means that each female carrying HIV can indirect pass the virus to *R* HIV-free females. Therefore if *R* > 1, the infection will outbreak; and will not otherwise. In this model setting where consistent use of male condom is the vectors for HIV transmission among females, $R = R_p R_h$, where $R_p = \beta_{ph} / \mu_1$ is the number of females that a contaminated male can transmit HIV to; and $R_h = \beta_{ph} / \eta$ is the number of males that a colonized female can pass HIV to (Austin et al., 1999; Cooper et al., 1999). We present the following proposition for the calculation of the equilibrium prevalence level y_p^*, which is based on Austin et al. (1999).

Proposition 1 *Suppose that* R_h *is negligible and* $\mu_0 \geq \mu_1$. *The equilibrium function* y_p *for colonized females is given by*

$$y_p^* = \frac{R + \alpha - \alpha\theta - 1 + \sqrt{(R + \alpha - \alpha\theta - 1)^2 + 4R\alpha\theta}}{2R} \tag{5}$$

where $\theta = \mu_0 / \mu_1 \geq 1$

Proposition we show the way to determine the HIV prevalence level y_p in equilibrium with the consideration of infection control efforts. In this proposal, we shall consider the infection intervention programs, designed to improve condom using, and their effectiveness on HIV transmission. With these programs, the speed of HIV transmission among females will be affected. In particular, we consider the scenario that males decide u condom sing compliance strategically (more details will be discussed in the next section). Basically, it is postulated that males are divided into two subgroups, one group using condom with a high compliance rate and the other group with a low compliance rate. We use *H* and *L* to denote the high and low compliance rates, respectively. For simplicity, we will use a "High Male" (or "High Males") and a "Low Male" (or "Low Males") to describe the member(s) of these two groups of males. Because of the difference in their compliance, the transmission rates from High and Low Males to females are also different, denoted by β_{hp}^H and β_{hp}^L, respectively, with $\beta_{hp}^H > \beta_{hp}^L$. Also, assume that the proportion of High Males among all males is p, then the (average) transmission rate β_{hp}^H from males to females in the transmission model can be represented as

$$\beta_{hp}^H = p\beta_{ph}^H + (1-p)\beta_{ph}^H, \tag{6}$$

and the decontaminated rate η can be represented in terms of the average using condom compliance of the males, which is

$$\eta = pH + (1-P)L \tag{7}$$

In the next subsection, we formulate a game theoretic model that describes how males make their strategic decisions regarding the condom using. In this model, we do not consider the intervention efforts in HIV transmission, which will be considered later.

3.2 Modeling strategic using a condom behavior: Evolutionary game

In our context, the players are the several males, and they need to decide using a condom level (high or low). Theoretically, a rational male should choose a using a condom compliance level based on the complete information about the condom using rate (η) and the HIV prevalence level (y_p). However, this information is not always available. Besides, the causal effect of one male's condom using level on the overall, group-level condom using rate and the spread of HIV is not immediately clear to the male. Furthermore, males have access to the information of HIV and studies have shown that peer influence is significant.

Therefore, the learning process, along with the interactions among males, is an important consideration in our setting for strategic males. Also from the consideration of HIV prevalence, the attention is on the average group condom using choice (e.g., the proportion of males choosing high condom using compliance), rather than an individual's decision. Accordingly, we employ the concept of evolutionary game theory (EGT) on the interactions of males. EGT, developed by Smith and Price (1973), was originally used to study the behavior of biological agents (e.g., insects and animals); but now has been widely applied in various fields, such as operations and supply chains (Xiao and Chen 2006, Kwon et al. 2009), marketing (e.g., Midgley et al. 1997, Xiao and Chen 2009), and entrepreneurship (e.g., Kuechle 2011). Using EGT, we derive the equilibria in terms of the proportion of males who maintains high condom using compliance. From studying the equilibria, we can able to interpret and come up with three motivations behind the male's strategic behavior: bandwagoning, altruism, and free-riding. Each male has two strategies: maintaining high or low condom using compliance. This compliance refers to the frequency of sexual activities within a fixed time period, which could be one day, one week, or one year (Won et al. 2004, Gould et al. 2007). The payoff matrix for male is constructed as in Table 1.

Table 1 Payoff matrix

	High	Low
High	$u_H - a, u_H - a$	$u_H - b, u_L - c$
Low	$u_L - c, u_H - b$	$u_L - d, u_L - d$

In this payoff matrix, u_H and u_L are the *perceived benefits* by males to conduct condom using with high and low adherence, respectively (related data will be collect form the Condom Use Self-Efficacy questionnaire in the educational intervention). The values of *a*, *b*, *c*, and *d* are the *costs* for maintaining condom using. We use the term "cost" to reflect the fact that maintaining condom using requires effort. From this matrix, we know for any randomly paired High (or Low) Males, each of their payoff is $u_H - a (or\ u_L - d)$.

If the pair consists of one High and one Low Male, their payoff will be $u_H - b$ for the High Male and u_L for the Low Male. The values of *a*, *b*, *c*, *d*, u_H, and u_L may not be arbitrary. There are two basic assumptions about their relative values:

- Maintaining high condom using is more beneficial than low condom using. This implies $u_H > u_L$.
- Maintaining high condom using requires more effort than low condom using. That is, $a > c$ and $b > d$.

The values of *a*, *b*, *c*, *d*, u_H, and u_L determine an individual condom using compliance, which will affect the proportion of High Males, denoted by p. This proportion will have influence on the average condom using compliance η, as shown in (7), and the speed of HIV transmission. Therefore, it is important to discuss how *p* changes over time and its equilibrium. In theory, each male tends to choose the condom using strategy that yields a higher payoff. Specifically speaking, *p* may evolve over time based on the payoff matrix and the interactions among males. Therefore, when Male 1 encounters Male 2 and if Male 1 notices his current choice is inferior to that of Male 2, Male 1 will switch to the superior strategy. The speed of strategy switching also depends on the payoff. That is, the larger the payoff, the faster the choice is switched. As a consequence, the proportion of the males with a higher payoff will become larger over time; because the males with a lower payoff will abandon their choice and adopt a new one to increase payoff. Accordingly, we use the concept of "replicator dynamics" in EGT to model the evolution of the proportion *p* over time (see Ginits, 2009). Let V_H be the payoff of High Males and $\bar{V}$ be the average payoff of all males. The replicator dynamics of the percentage of High Males can be expressed as follows:

$$\dot{p} = p(V_H - \bar{V}), \tag{8}$$

where $\dot{p}$ is the time derivative of the proportion of High Males. The rationale of (8) is that if the payoff of High Males is higher than the average, the proportion of High Males will grow over time, and vice versa.

From the payoff matrix, the expected payoff V_H of High Males is

$$V_H = p(u_H - a) + (1 - p)(u_H - b) \tag{9}$$

Likewise, the expected payoff V_L for Low Males is

$$V_L = p(u_L - c) + (1 - p)(u_L - d) \tag{10}$$

So the average payoff $\bar{V}$ for all the males is

$$\bar{V} = pV_H + (1 - p)V_L. \tag{11}$$

Therefore, the dynamics of the group of High Males in (8) is reduced to

$$\dot{p} = p(V_H - \bar{V}) = p(1-p)\left[u_H - u_L - p(a-c) - (1-p)(b-d)\right]. \qquad (12)$$

Lemma 1 *There exist three fixed points for the dynamic system described in (12):* $p_1^* = 0$, $p_2^* = 1$, and

$$p_3^* \equiv \frac{u_H - u_L - (b-d)}{a - c - (b-d)} \qquad (13)$$

Note that p_3^* *is between 0 and 1 when (i)* $a - c \neq b - d$ *; and (ii) either* $b - d < u_H - u_L < a - c$ *or* $a - c < u_H - u_L < b - d$ *holds.*

Given the fixed points in the lemma, the next step is to examine whether each of them is an evolutionary stable strategy (ESS), in which no small group of Males using an alternative strategy can "invade" and change the current proportion of High Males (see Ginits, 2009). In other words, ESS is the outcome of the diffusion of forms of males' condom using behavior. The result is summarized as follows.

Proposition 2 *Let* $p(0)$ *be the initial proportion of High Males at time* 0*. Then the following ESS equilibria to the dynamic system described in (12) exist for different ranges of* $u_H - u_L$*:*

(i). *For* $u_H - u_L < a - c$ *and* $u_H - u_L < b - d$ *: the equilibrium outcome is* $p^* = 0$*;*

(ii). *For* $u_H - u_L > a - c$ *and* $u_H - u_L < b - d$ *: the equilibrium outcome is* $p^* = 0$*; if* $p(0) \le p_3^*$*; otherwise,* $p^* = 1$*;*

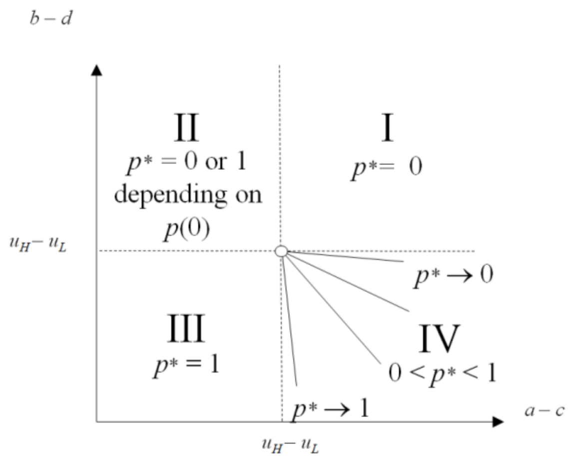
(iii). *For* $u_H - u_L > a - c$ *and* $u_H - u_L > b - d$ *: the equilibrium outcome is* $p^* = 1$*;*

(iv). *For* $u_H - u_L < a - c$ *and* $u_H - u_L > b - d$ *: the equilibrium outcome is* $p^* = p_3^*$.

The result of this proposition is depicted in Figure 2, in which both the horizontal and vertical axes represent the "cost differentials" for condom using *a-c* and *b-d*, respectively. By comparing these two cost differentials with the perceived "benefit differential" ($u_H - u_L$), the four regions I to IV can be identified. Proposition 2 states that in Region I (or III), the only ESS is $p^* = 0$ (or $p^* = 1$). In Region II, the ESS can be either $p^* = 0$ or $p^* = 1$, depending on the initial p value, $p(0)$. In Region IV, the ESS allows p^* to be any value between 0 and 1. Any point on a ray in this region starting from ($u_H - u_L, u_H - u_L$) has the same p^* value ($p^* = p_3^*$). When the ray is nearly horizontal (or vertical), the p^* value approaches to 0 (or 1). Note that p^* is undefined at the starting point of all rays in Region IV. Next we interpret the result of Proposition 2 by regions.

Region I corresponds to $u_H - a < u_L - c$ and $u_H - b < u_L - d$ in Proposition 2*(i)*. In this region the payoff for High Males is always lower than that for Low Males. In this situation, even if there may be some High Males initially, after knowing that the lower condom using can yield a higher payoff, everyone eventually becomes a Low Male. So the ESS is $p^* = 0$. The interpretation of Region III is opposite to that of Region I. In Region II, the relationship of the payoff is $u_H - a < u_L - c$ and $u_H - b < u_L - d$, corresponding to Proposition 2*(ii)*. Region II describes the situation where a male has a higher payoff to choose high adherence when knowing the other male also chooses high adherence. What is interesting is that if the other male chooses low adherence, this male would then feel choosing low adherence yields a higher payoff. One possible explanation is the bandwagoning effect, which indicates that the male is attracted to join the existing "party" (or proportion) of males with a certain type of condom using strategy. Specifically, if the proportion of High Males exceeds some critical mass initially, more males will "*jump on the bandwagon*" such that the High Males eventually expand to the whole (i.e., leading to an ESS of $p^* = 1$); otherwise, the cohort of the High Males will eventually disappear (i.e., $p^* = 0$). So in this region, two ESS's, $p^* = 0$ and 1, are possible as predicted in Proposition 2*(ii)*. In Figure 3, Region II is enlarged and a shaded area is displayed. The distance between any point on the curved boundary of the shaded area and ($u_H - u_L, u_H - u_L$) is the corresponding p_3^*. Given point A located in Figure 3 based on the payoff matrix value, a ray is drawn from ($u_H - u_L, u_H - u_L$) to pass this point. The initial value of p, $p(0)$, is represented in terms of the exact length from the start point along the ray. If $p(0)$ falls within the shaded area, then the initial proportion of High Males is not large enough to sustain the evolution and $p^* = 0$; otherwise $p^* = 1$. The boundary of the shaded area captures the critical mass of $p(0)$ required to trigger full compliance of the entire group of males (i.e., $p^* = 1$). Region IV corresponds to $u_H - a < u_L - c$ and $u_H - b < u_L - d$ in Proposition 2*(iv)* where a male would prefer low adherence when knowing that the other males are of high compliance. Furthermore, the male prefers high adherence when knowing that others choose low adherence. Contrary to Region II, the male seems to prefer exactly the opposite of what others choose. Why? This may be interpreted from two different motivations for condom using: free riding and altruism.

Since the HIV prevalence depends on the *overall* safety sex behavior and condom using adherence, if the other males use a condom with high compliance, the male may conceive a lower risk for cross-transmission among females and want to be a free-rider by maintaining low adherence. On the other hand, if the other males use a condom with low compliance, the sense of altruism may push the male to maintain high compliance to prevent the spread of HIV transmission from threatening the safety of the females. One may also argue that altruistic behavior may be supported by self-interests (e.g., Batson and Powell 2003; Simon 1990). In this situation, the self-interest may simply be the sense of self-protection: “Since other males are not use a condom, I’d better use a condom more seriously to protect myself.” Proposition 2*(iv)* predicts that the ESS is a partial adherence of the males, i.e., a p^* between 0 and 1. That means, a p^* proportion of High Males are altruists and $(1 - p^*)$ males are free riders. To be more precise, the motivation of condom using behavior is a combination of altruism and free-riding; and which would prevail depends on its expected payoff. Mathematically, it can also be interpreted that each male plays a mixed strategy, with a chance of p^* to play High (to be altruistic) and a chance of $(1 - p^*)$ to play Low (to be a free-rider). If the point corresponding to the payoff matrix is located close to Region III, then the majority of males are altruists in the equilibrium. When the point is closer to Region I, most Males are free-riders.



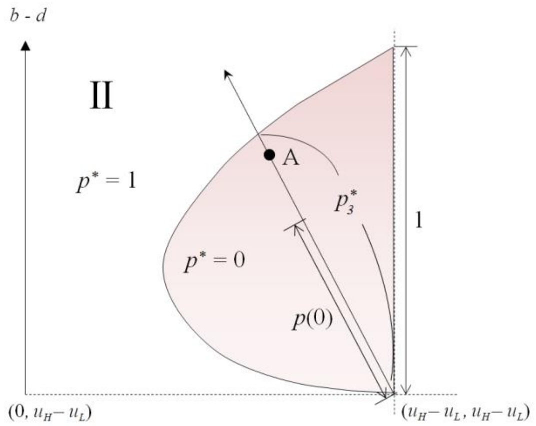


Figure 2 The four regions for the equilibrium p^* Figure 3 In Region II, p^* depends on the initial value $p(0)$

The above analysis indicates that a full compliance ($p^* = 1$) is achievable only when the benefit differential ($u_H - u_L$) exceeds at least one cost differential (*a* - *c* or *b* - *d*); otherwise $p^* = 0$ as in Region I. When compliance does exist, the males’ strategic behavior may be understood from three different motivations of condom using: bandwagoning, altruism, and free-riding. Ultimately, the payoff matrix decides which motivation will prevail. From psychology literature, motivations can be intrinsic and extrinsic (Eccles and Wigfield, 2002). In this year, the payoff matrix describes both the intrinsic and extrinsic motivations of males’ condom using. The intrinsic motivation implies that the males use a condom for their own purposes such as altruism and self-protection; whereas the extrinsic motivation comes from the fact that males may use a condom merely for asking the requirements of the sexual partner. Therefore, in the next section we discuss using the methods of education to affect both the intrinsic and extrinsic motivations of the males to achieve the desired condom using compliance.

3.3 Optimal solution of intervention policy

In this section, we focus on Region III where males reveal opportunistic behavior. To reduce the motivation of being a free rider, we will arrange a group of trained intervention to observe and record males’ condom using compliance periodically. The investigators randomly chose males for condom using observation. If an investigator observes a male not maintaining the required condo using, the male will receive a punishment. To model the intervention program, we assume that the time between noncompliance events follows an exponential distribution with a rate parameter λ. As argued previously, each male plays a mixed strategy with p^* probability choosing the High strategy and $(1-p^*)$ probability choosing Low, so we approximate the arrival rate of the noncompliance events as

$$\lambda = k \cdot (1-p^*), \tag{14}$$

where k is a constant rate that describes the number of condom using opportunities per time period. Namely, the rate that a noncompliance occurs is proportional to the probability that each male plays Low. If a male is observed not to use a condom within T, the male will receive a punishment of u_N. If T is long, the chance to catch noncompliances is high; but the number of males that an investigator can monitor becomes less within a fixed time. During the period T, the probability that at least n noncompliance events are spotted is denoted by

$$r(T) = 1 - \sum_{i=0}^{n-1} \frac{e^{-\lambda T} (\lambda T)^i}{i\ !}, \tag{15}$$

In our model, with the investigate program the potential penalty $r(T)u_N$ is added to the cost of the Low strategy. The payoff matrix is modified in Table 2.

Table 2 Payoff matrix with inspection

	High	Low
High	$u_H - a, u_H - a$	$u_H - b, u_L - c - r(T)u_N$
Low	$u_L - c - r(T)u_N, u_H - b$	$u_L - d - r(T)u_N, u_L - d - r(T)u_N$

The purpose of the penalty is to provoke behavior change and, hopefully, to ultimately lift p_3^* to one. From (13) we know the new p_3^* after the update of the payoff matrix, denoted by $\hat{p}_3^*$, is

$$\hat{p}_3^* = \frac{u_H - u_L - (b-d) + r(T)u_N}{a - c - (b-d)}, \tag{16}$$

Therefore, if one wants $\hat{p}_3^*$ to be able to reach 100% via interventions, u_N must be big enough to make up the difference between the denominator and the numerator in (16). That is, one must have $u_N > (a-c) - (u_H - u_L)$, which is a necessary condition. With the consideration of the intervention policy implemented by the health provider, we construct a Stackelberg (leader-follower) game. In the first stage of the Stackelberg game, the health provider decides the overall intervention duration T to minimize its total cost. We define C_I as the intervention related cost and C_a as the condom accessibility cost. Let C be the total cost. We have

$$C = C_I \cdot T + C_a \cdot y_p^*, \tag{17}$$

which describes the objective function in the first stage. For the males, knowing the intervention policy T, they decide condom using compliance rate (High or Low) in the second stage as in Section 3.2. In order to find the equilibria, we solve this game in a backward manner, the second stage first. Like in the basic model, the second stage game of this model is also an evolutionary game. Given the first stage decision T, the following two parameters are defined as:

$$\hat{c} \equiv \quad c + r(T)u_N \tag{18}$$

$$\hat{d} \equiv \quad d + r(T)u_N \tag{19}$$

where $\hat{c}$ and $\hat{d}$ are implicit functions of T. Given T, it is clear that the evolutionary game in stage is no different from the basic model in Section 3.2 with the values of $\hat{c}$ and $\hat{d}$ in Table 1 replaced by $\hat{c}$ and $\hat{d}$ and defined above. In the first stage, as the intervention policy T, it would take time for the males to adjust their condom using strategy, which results in an equilibrium of the males' noncompliance rate λ. To find the equilibrium λ, we solve the following equation:

$$\lambda = k \cdot (1 - p_3^*) = k(1 - \frac{u_H - u_L - (b-d)}{(a-c)-(b-d)} \tag{20a}$$

$$= k(1 - \frac{u_H - u_L - (b-d) + (1 - \sum_{i=0}^{n-1} e^{-\lambda T} (\lambda T)^i / i\,!) u_N}{(a-c)-(b-d)}) \tag{20b}$$

Solving λ in (20) is essentially equivalent to finding the root of a one-dimensional function, which can be done easily. Using the equilibrium λ to determine p_3^*, and plugging it into (6) - (7), one can determine the equilibrium prevalence level y_p^* via (5), by plugging in p with $\hat{y}_p^*$. Therefore, y_p^* can be viewed as an implicit function of *T*; and in the first stage, solves the following problem by choosing the optimal T：

$$T^* = \arg\min_T C_I \cdot T + C_a \cdot y_p^*(T), \tag{21}$$

where both C_I and C_a are constant.

Note that (21) describes a one-dimensional global optimization problem, which is manageable using computing tools. Unfortunately, the closed-form solution of the optimal *T* is not available. We shall use the numerical method to solve it. Basically, as the interval T increases, more males become High Males (p^* increases); therefore, average condom using rate η increases; and the HIV infection prevalence y_p^* decreases. It will be shown in the next section that as *T* continues to increase, the marginal improvement of y_p^* decreases.

4 Discussion

In the previous sections, we have demonstrated the existence of an ESS in which male reveal an opportunistic condom using behavior. This section will focus on the effects of these control programs and discuss how these programs can increase the value of p^*. Since p^* is equilibrium in the context of an evolutionary game, our implicit assumption is that the evolution of the strategic behavior of the male is ongoing and continuous. That is, the introduction of a new intervention or adjustment of the existing ones can induce behavioral changes of the males and possibly a new equilibrium of p^*.

4.1 Effect of interventions on using condom strategic behavior

A male who "*jumps on the bandwagon*" does what the majority of males do, as the situation is described in Region II of Figure 2. There are two possible reasons for a male to be bandwagoning. The first reason is that the male's condom using choice is influenced by peer pressure. That is, the male feels compelled to do what others do to conform to the group norms. The other explanation is that the male may assume those who have chosen condom using strategy may have done the necessary consideration to make a wise decision. The purpose of promoting role models is to make the bandwagoning males know whom they should learn from and feel that many males use a condom with high compliance. By doing so, hopefully the males will follow the role models and become part of the group with high compliance. As the proportion of High Males grows to exceed the critical mass described in Figure 3, an ESS of $p^* = 1$ can be ensured. A question that also needs to be considered is which type of male is the more appropriate choice to select as role models. An altruistic male maintains high condom using compliance to prevent the spread of HIV transmission and reduce the risk to be infected. Namely, the condom using is motivated by the benefit to the males. Generally, health provider can promote altruism by making it easier to be altruistic for males. To do so, health provider can reduce the conduct condom using ($a-c$ and $b-d$ in the payoff matrix). Furthermore, to induce more males to be altruists, the health provider can provide concrete evidence about the effectiveness of using condom in intervention via educational sessions.

Figure 4 shows how these changes can affect the proportion of High Male. Consider point B in Figure 4, where only a part of the males are High Males in the ESS. With the decreased the cost of maintaining condom using, the values of $a-c$ and/or $b-d$ are decreased, which helps to move point *B* southwest to B' and results in an increased proportion of High Males in the equilibrium. Lowering the condom accessibility cost can also positively influence the points in the other regions, such as moving points A in Region II and C in Region I toward A' and C', respectively, as shown in Figure 8. In Region II where the equilibrium may not have been settled yet, a lower condom accessibility cost helps to decrease the threshold of the critical mass and makes it easier to achieve $p^* = 1$. On the other hand, in Region I where males have no incentive to maintain high condom using, the point C', at least, is closer to either Region III and Region IV, where $p^* > 0$ is possible. Note that both Regions I and II, where the ESS is $p^* = 0$, in which an intervention failed to increase males' condom using compliance. Our model indicates that the efforts must exceed a certain threshold (i.e., to reach beyond the boundaries of Regions I and II) to achieve an outcome with visible condom using compliance ($p^* > 0$). Another approach that health providers can do is to use educational sessions to improve the use a condom of males. The objective of such education is to enhance males' confidence that using condom is essential in reducing the HIV prevalence level. In terms of our model, the purpose of the education is to increase the benefit differential of condom using, i.e., $u_H - u_L$. How the increase of $u_H - u_L$ enhances the proportion of High Males is depicted in Figure 5. Consider point B in Region IV of Figure 5(a), where $p^* < 1$. Lifting the value of $u_H - u_L$ is equivalent to moving the whole picture northeast (along the 45 degree line) with the points A, B, C unchanged (because they are only related to the values of the payoff matrix), as shown in Figure 5(b). It can be seen that after the move (due to the effectiveness of the educational sessions), the new ESS of B is closer to Region III, indicating a higher p^* value.

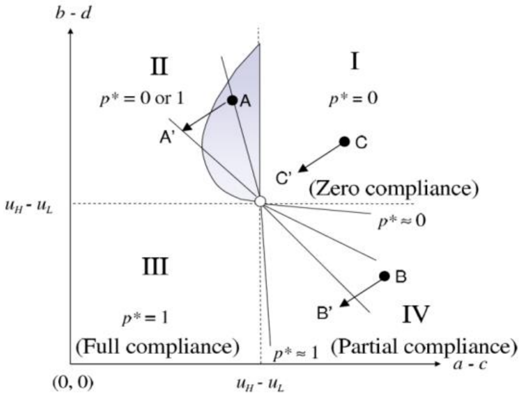


Figure 4 The effect of lowering condom using cost

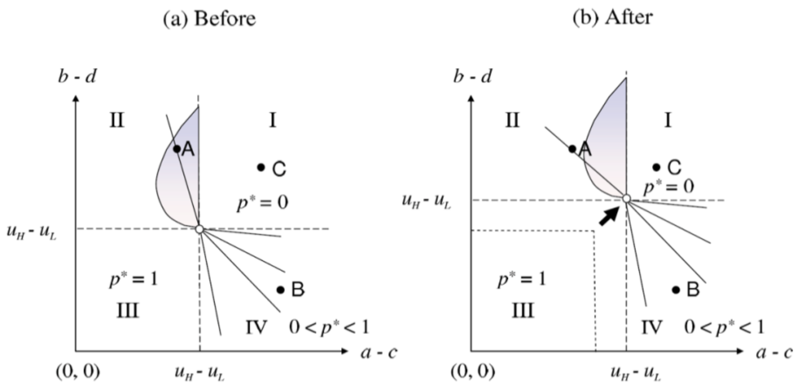


Figure 5 The effect of educational sessions

Educational sessions also have positive effects on point A in Region II and point C in Region I. Similar to the effect of lower condom accessibility cost discussed above, education and training makes it easy to achieve $p^* = 1$ in Region II and helps to reduce the gap between the benefit differential and the cost of condom using in Region I. Free-riding males use a condom with low compliance because they believe that with the efforts of other males, the risk of infection transmission and HIV prevalence is low. Therefore, they can take a free ride on the High Males. In order to weaken males' free-riding motivation, the health providers can underline the role of safety sex behavior as a means of self-protection via educational sessions, as discussed and shown in Figure 5. This way is equivalent to increasing the benefit differential from $u_H - u_L$ to $u_H - u_L + ru_N$, where r is the probability of being caught and u_N is the negative result.

4.2 Effect of inspection policy on HIV prevalence level

We conduct a numerical study to demonstrate (i) How the intervention policy reduces males' opportunistic behavior, (ii) How males' condom using compliance affects the HIV prevalence level, and (iii) A sensitivity analysis of the factors affecting the HIV prevalence level. To test our integrative model, we have constructed a case study that is as close as possible to a real case. The parameter values used in the case are collected from the literature. We assume 6 females; and there are 10 males. The contact between females and each male is assumed to be 60 times per year on average (Kingnet, 2015). The compliance of condom using is 8% for Low males and 66% for High males (Durex Global, 2015). This means that a Low male using condom 4.8 times per year; and a High male 39.6 times per year. So we set H = 40 and L = 5. To determine the transmission rates, which is determined by the probability of transmission by contact, multiplied by the number of effective male-female contact, an effective contact is a contact without disinfection. This translates to 20.4 (= 60-39.6) effective contacts for a High male and 55.2 (= 60-4.8) for a Low male. Assuming that each male have β_{hp}^{H} = 20.4/(6× 10) = 0.34, β_{hp}^{L} = 55.2/(6× 10) = 0.92; and β_{hp} =1. The condom cost for each time is \$100 per time (Kingnet, 2015); so the total is \$600/year. The intervention cost per day C_I should be smaller than C_T We assume that C_I is \$60/time for each instructor in the baseline case. Later we will also perform the sensitivity analysis on C_I . For the payoff matrix, although there are six parameters a, b, c, d, u_H , and u_L , only three values are useful: $a-c$, $b-d$, and $u_H - u_L$. Furthermore, since what matters is their relative values, we conveniently assume $u_H - u_L$ = 10, a − c = 13, and b − d = 9. It can be verified that the point corresponding to this payoff matrix is located in Region IV of Figure 2 (closer to Region I than III). This is because we would like to focus on males' strategic behavior with p^* between 0 and 1. In this setting, the current High males only account for 25% of the males (i.e., p^* = 25%). For (15), assume there is only one intervention, who can monitor the condom using opportunities of a randomly picked male each time. So we set $\lambda = k(1- p^*)$, with k = 60 per year. We also assume the penalty u_n = 5 in the baseline.

Figure 6 describes how the proportion of High males (p^*) changes with the intervention period T. When T increases, the chance that a free-rider is caught becomes higher. Once a free-rider is caught, the penalty lowers his payoff; therefore, we can predict that more free riders would be converted to High males. Therefore, p^* increases with the intervention period T. The increase, however, tapers off as T further increases. This implies the effectiveness of intervention because it becomes harder and harder to spot noncompliances as p^* increases, as described in (14). This observation suggests that interventions cannot be the sole implementation and must work hand-in-hand with other interventions such as education and training to achieve full compliance. Figure 6 also shows the effectiveness of the increase of p^* by increasing the penalty u_n, which is increased from 1 to 10, corresponding to 10% to 100% of the benefit differential ($u_H - u_L$). Intuitively, the higher the penalty, the higher the proportion of High males p^* can be induced. However, Figure 6 also shows that when the penalty is too light, less than 30% of the benefit differential, p^* may not converge to 100% even with an extended intervention duration T, and, therefore, is not effective. This observation is consistent with (16) because $(a − c) − (u_H - u_L)$ = 3.

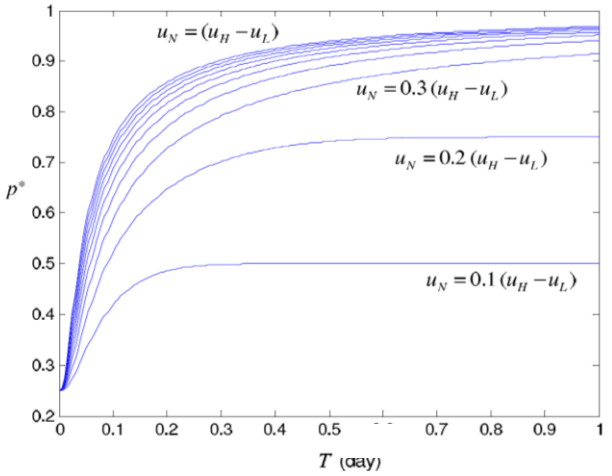


Figure 6 The proportion of High males p^* by changing the intervention time T and the penalty u_n

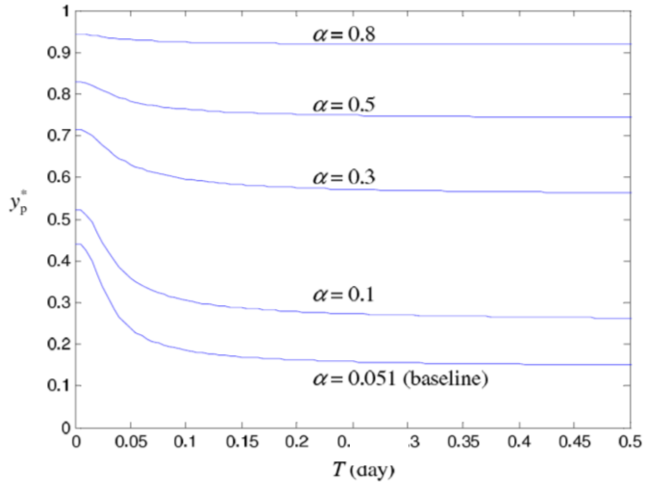


Figure 7 The prevalence level y_p^* by changing T

Figure 7 shows the influence of males' condom using compliance on the HIV prevalence level. When the intervention period T increases, the proportion of High males also increases as shown in Figure 6. As a result, the HIV prevalence level y_p^* decreases. However, there is another factor that can also affect y_p^*, which is the percentage of newly females with colonization α. To show the influence on y_p^*, the value of α is varied from low (e.g., 10%) to high (e.g., 80%). First, consider the HIV prevalence level y_p^* when $T = 0$, i.e., no intervention. It can be seen that y_p^* increases with α. After the university invests resources in interventions, it becomes evident that the intervention can decrease the prevalence level. More specifically, the intervention can yield significant improvement when α is small, but has little effect on the prevalence level when α is large. Since condom using mainly decreases the cross-transmission among individuals, it does not help if the majority of females are already colonized (even without the cross-transmission). This does indicate the limit of condom using in terms of reducing the HIV prevalence level y_p^*. Figure 8 shows the corresponding total cost of the result displayed in Figure 7. It can be seen when α is small (e.g., α =10% and 30%), the intervention can yield a lower total cost. In Figure 9 we revisit the effect of the penalty. The effect of the penalty on the optimal intervention duration T^* (dotted line) that balances the intervention cost. Generally, when the penalty increases, the optimal duration T^* decreases. This implies that using a penalty can actually lower the total cost. This is confirmed in the other solid curve, which shows that the optimal total cost decreases as the penalty increases. From Figure 6, we have learned that the penalty should not be too light. When the penalty is more than 30% of the benefit differential of condom using, the marginal cost reduction tapers off. This implies that using the penalty *per se* is not a direct method to lower costs, but to induce behavior change, which is the real driver of the cost reduction. Since the penalty only acts as a catalyst, it should be neither harsh nor light. In this case, from Figures 6 and 8 it seems that a penalty of 40%-50% of the benefit differential is appropriate.

Next we consider the sensitivity analysis on changing the parameters of the objective function (21) and see how it affects the optimal intervention policy. Since the objective function only has two coefficients: unit intervention cost C_I and unit treatment cost C_T , we consider the sensitivity analysis by changing their ratio C_I / C_T (with C_T = \$600 fixed). In general, $C_I \leq C_T$, otherwise it would not be economical to consider interventions. It can be expected that the cheaper the intervention is, the more the intervention will be used. By varying the ratio of C_I / C_T between 0.1 and 1, in Figure 10 we display the change of the optimal inspection period T^* and the corresponding p^*, y_p^*, and the minimal total cost $C(T^*)$. In each sub-figure, four α values are also considered. In Figure 10(a), in general the value of the optimal T increases as C_I becomes relatively cheaper than C_T. When the value of α is small, the curve of the optimal inspection duration T^* is a convex, downward sloping function, indicating the speed of the increase of T^* outpaces the decrease of the inspection cost C_I. This implies that T^* is mainly determined by the cost consideration. However, as α continues to increase, ultimately the optimal T suddenly turns flat, meaning no intervention is economical. Again, this indicates that each intervention has its limit in dealing with a certain arrival rate of colonized females. The behavior of other dependent variables p^*, y_p^*, and the total cost C are typical: as α increases, p^*

decreases, y_p^* increases, and the total cost C increases (due to the decrease of C_I).

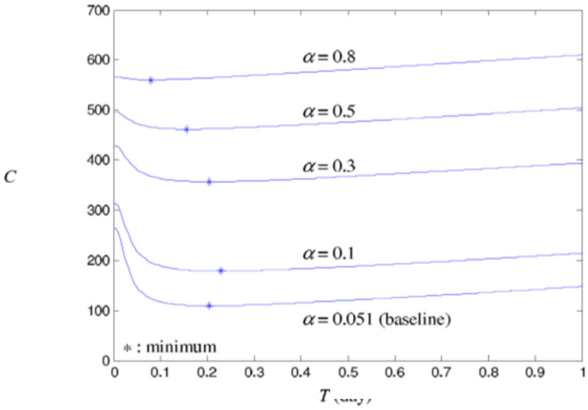


Figure 8 The total cost C by changing T

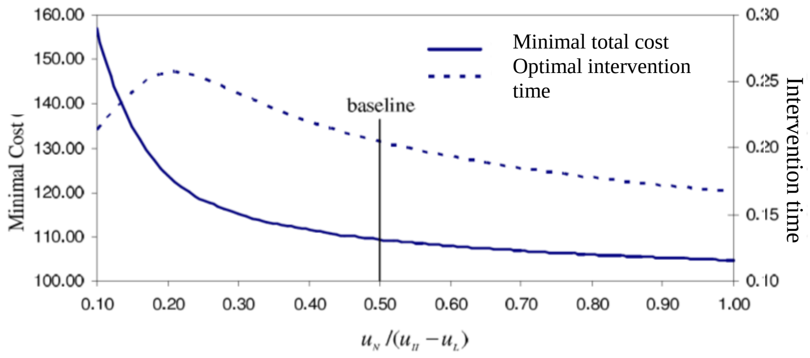


Figure 9 Optimal intervention time

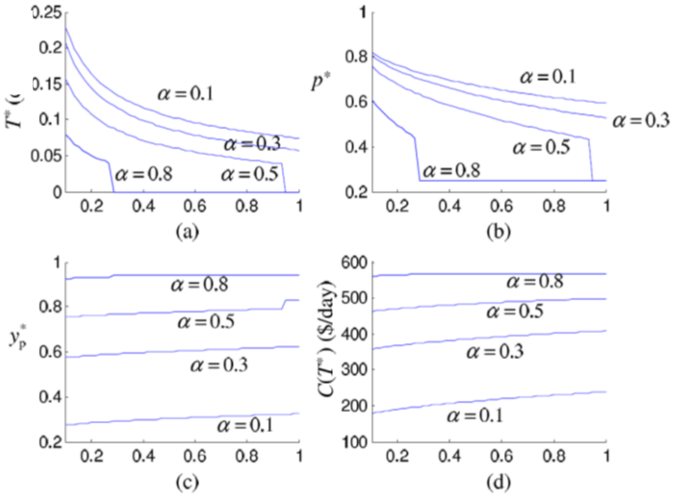


Figure 10 Sensitivity analysis by changing the objective parameters C_I / C_T

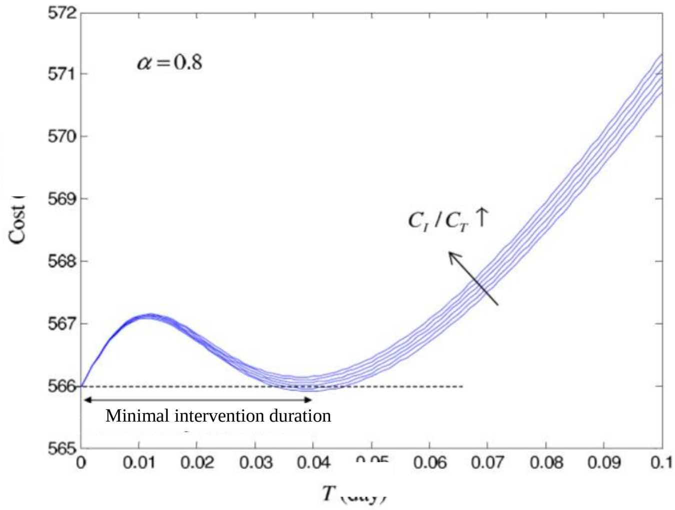


Figure 11 Explanation of abrupt change of T^* as C_I / C_T increases (α = 0.8).

What is interesting is that all four sub-figures show a standstill unless the intervention cost is very low when α = 0.8. There is a level of C_I beyond which the optimal intervention time T^* is suddenly reduced to 0. This is explained in Figure 11, which displays the typical cost function $C(T)$ around the C_I values where the abrupt change occurs: the cost first increases as the intervention is deployed; then decreases as the benefit starts to materialize; and finally reaches a minimum. This implies that a minimum level of effort and investment are required to change male's strategic behavior to the desired level. When C_I is increased, to some extent, the minimal cost incurred from the intervention starts to exceed that of doing nothing. The optimal decision is to stop doing the intervention; therefore, T^* drops from around 0.04 (year) directly to 0.

5 Conclusions

Our solution approach overcomes the shortcomings of traditional epidemiological modeling by formulating strategic males using an evolutionary game embedded in a transmission dynamics model. Our model indicated there are three possible equilibria: zero compliance, partial compliance, and full compliance among all males, through which we are able to explain "*why don't interventions work as expected?*"

If the bandwagoning motivation is managed properly, it can lead to full compliance, otherwise nil. The strategic behavior may improve the prevalence level of HIV.

Given the lack of reliable data on input parameters about strategic males, our objective is to generate the insights that are relatively robust to change in the absolute values of these parameters. We believe that the qualitative impact of interventions on the levels of HIV and males should remain unchanged although the absolute magnitude of these effects might vary.

科技部補助專題研究計畫出席國際學術會議心得報告

日期：105 年 10 月 25 日

計畫編號	MOST 104-2633-E-040 -001 -		
計畫名稱	HIV/AIDS 的移動迷宮：關於你的秘密!(I)		
出國人員姓名	張啟昌	服務機構及職稱	中山醫學大學醫學資訊學系
會議時間	105 年 7 月 1 日至 105 年 7 月 3 日	會議地點	雅典
會議名稱	(英文)14th International Conference on Informatics, Management and Technology in Healthcare		
發表題目	(中文) 以影片衛教介入方法提升大學生使用保險套 (英文) Evaluation of a Video-based Intervention to Promote Condom Use among College Students in Taiwan		

一、 參加會議經過

2016 年 14th International Conference on Informatics, Management and Technology in Healthcare 年會在雅典召開。本次的年會為期三天，會議的前二天主要是一些 Technical Session，而後從第三天下午開始則是 Workshop 與 poster sections 的議程，所有的作者一一上台報告論文；而在各個 Session、Workshop 間則是會有許多的 Keynote speech 以及 Panel Discussion，讓世界各國的學者都可以與主題的討論，做學術上的交流。

二、與會心得

以往參與的研討會，時有機會聆聽外國學者專題演講，從傾聽國外學者的研究報告與分享自己研究的經驗，討論的範圍很廣且互動熱烈。此次得以出國參加學術研討會，使我有機會接觸其他國家的文化觀點，今後面臨研究的問題時，能有更宏觀的思考方向，我想，這是古人所謂「行萬里路，勝讀萬卷書」的意涵！唯有進入情境之中，方能有深入的理解與體會。總而言之，這是一次相當成功的會議。以我個人而言，不僅見到許多以前在國際會議中熟識的大師與學者，彼此交換近來的經驗與資訊；更與許多素未謀面的人士因共同的話題，互相切磋觀摩而結良友。

三、發表論文全文或摘要

個人的發表論文題目為 以影片衛教介入方法提升大學生使用保險套，許多學者前來詢問研究設計，並針對個人的研究展示高度的興趣。這是我第一次參加 International Conference on Informatics, Management and Technology in Healthcare 所主辦的國際學術研討會，此次得以出國參加學術研討會，以我個人而言，可以直接談論跨國際研究的合作事宜，收穫非常豐碩。

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Abstract. Almost of HIV/AIDS cases in Taiwan occur in the age range of 20 to 29 yrs. Many of the reported cases are in the college-age and infection might have occurred through unprotected sexual behaviors. This study was to identify the effectiveness of a video-based intervention has important implications for health provider to plan evidence-based address the specific needs of college students. The research design of this study was based on Transtheoretical Model (TTM). In addition, through an experimental design with groups: (i) to evaluate the effectiveness of a video-based intervention on the TTM stages of change, condom use self-efficacy, perceived benefits of and barriers to condom use by Taiwanese college students and (ii) to explore the factors affecting the TTM constructs for condom use. Overall, students have higher score in the pretest HIV knowledge scale, pretest self-efficacy scale and perceived benefits scale than the posttest. The score in perceived barriers scale of condom use also reduced after receiving intervention. This result shows that the videos and health education intervention can be effective in changing the college's intention to use condoms.

四、攜回資料名稱及內容

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科技部補助專題研究計畫出席國際學術會議心得報告

日期：105 年 10 月 25 日

計畫編號	MOST 104-2633-E-040 -001 -		
計畫名稱	HIV/AIDS 的移動迷宮：關於你的秘密!(I)		
出國人員姓名	張啟昌	服務機構及職稱	中山醫學大學醫學資訊學系
會議時間	105 年 7 月 1 日至 105 年 7 月 3 日	會議地點	雅典
會議名稱	(英文)14th International Conference on Informatics, Management and Technology in Healthcare		
發表題目	(中文) 以影片衛教介入方法提升大學生使用保險套 (英文) Evaluation of a Video-based Intervention to Promote Condom Use among College Students in Taiwan		

一、 參加會議經過

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科技部補助計畫衍生研發成果推廣資料表

日期:2016/10/25

科技部補助計畫	計畫名稱: HIV/AIDS的移動迷宮：關於你的秘密!(I)	
	計畫主持人: 張啟昌	
	計畫編號: 104-2633-E-040-001-	學門領域: 作業研究

無研發成果推廣資料

104年度專題研究計畫成果彙整表

計畫主持人：張啟昌					計畫編號：104-2633-E-040-001-		
計畫名稱：HIV/AIDS的移動迷宮：關於你的秘密!(I)							
成果項目					量化	單位	質化（說明：各成果項目請附佐證資料或細項說明，如期刊名稱、年份、卷期、起訖頁數、證號...等）
國內	學術性論文	期刊論文			0	篇	
		研討會論文			0		
		專書			0	本	
		專書論文			0	章	
		技術報告			0	篇	
		其他			0	篇	
	智慧財產權及成果	專利權	發明專利	申請中	0	件	
				已獲得	0		
			新型/設計專利		0		
		商標權			0		
		營業秘密			0		
		積體電路電路布局權			0		
		著作權			0		
		品種權			0		
		其他			0		
	技術移轉	件數			0	件	
		收入			0	千元	
國外	學術性論文	期刊論文			0	篇	
		研討會論文			1		
		專書			0	本	
		專書論文			0	章	
		技術報告			0	篇	
		其他			0	篇	
	智慧財產權及成果	專利權	發明專利	申請中	0	件	
				已獲得	0		
			新型/設計專利		0		
		商標權			0		
		營業秘密			0		
		積體電路電路布局權			0		
		著作權			0		
		品種權			0		
		其他			0		

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<tr><td>碩士生</td><td>0</td><td></td></tr>
<tr><td>博士生</td><td>0</td><td></td></tr>
<tr><td>博士後研究員</td><td>0</td><td></td></tr>
<tr><td>專任助理</td><td>0</td><td></td></tr>
<tr><td rowspan="5">非本國籍</td><td>大專生</td><td>1</td><td></td></tr>
<tr><td>碩士生</td><td>1</td><td></td></tr>
<tr><td>博士生</td><td>0</td><td></td></tr>
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<tr><td>專任助理</td><td>0</td><td></td></tr>
<tr><td colspan="3">其他成果
（無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。）</td><td colspan="3"></td></tr>
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科技部補助專題研究計畫成果自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現（簡要敘述成果是否具有政策應用參考價值及具影響公共利益之重大發現）或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估

■達成目標

□未達成目標（請說明，以100字為限）

　　□實驗失敗

　　□因故實驗中斷

　　□其他原因

說明：

2. 研究成果在學術期刊發表或申請專利等情形（請於其他欄註明專利及技轉之證號、合約、申請及洽談等詳細資訊）

論文：□已發表　□未發表之文稿　■撰寫中　□無

專利：□已獲得　□申請中　■無

技轉：□已技轉　□洽談中　■無

其他：（以200字為限）

3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性，以500字為限）

Our solution approach overcomes the shortcomings of traditional epidemiological modeling by formulating strategic males using an evolutionary game embedded in a transmission dynamics model. Our model indicated there are three possible equilibria: zero compliance, partial compliance, and full compliance among all males, through which we are able to explain “why don’t interventions work as expected?”

4. 主要發現

本研究具有政策應用參考價值：■否　□是，建議提供機關

（勾選「是」者，請列舉建議可提供施政參考之業務主管機關）

本研究具影響公共利益之重大發現：■否　□是

說明：（以150字為限）

If the bandwagoning motivation is managed properly, it can lead to full compliance, otherwise nil.