National Centre in HIV Epidemiology and Clinical Research

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Policy Document

Evaluation of the potential impact of the global economic crisis on HIV epidemics in Southeast Asia

David Wilson, Richard Gray, Kelly-Jean Heymer, Alexander Hoare, Jisoo Kwon, Hla-Hla Thein, Heather Worth, John Kaldor

Background

Economic conditions around the world are likely to deteriorate in the short to medium term. The potential impact of this crisis on the spread of HIV is not clear. Government revenues and aid flows from international donors may face constraints, possibly leading to reductions in funding for HIV programs. Economic conditions (leading to increases in unemployment, for example) may also have an indirect impact on HIV epidemics by affecting the behaviour of individual people. Some behavioural changes may influence the rate of HIV transmission.

This report presents findings from a study that investigates the potential impact of the economic crisis on HIV epidemics through the use of mathematical modelling. The potential epidemiological impacts of changes in the economy are explored for two distinctly characterised HIV epidemics: (i) a well-defined, established, and generalised HIV epidemic (specifically **Cambodia**, where incidence is declining); (ii) an HIV epidemic in its early expansion phase (specifically **Papua New Guinea**, where incidence has not yet peaked). Country-specific data are used for both settings and the models calibrated to accurately reflect the unique HIV epidemics in each population in terms of both incidence and prevalence. Models calibrated to describe the past and present epidemics are then used to forecast epidemic trajectories over the next few years under assumptions that behavioural or program conditions may change due to economic conditions.

It should be noted that there are very limited solid data on how HIV/AIDS program funds may decrease or how social determinants related to HIV risk may change due to the economic crisis. Potential changes in key relevant factors were explored, along with sensitivity ranges around these assumptions, based on extensive discussions with in-country and international experts and stakeholders. As with all mathematical models, assumptions should be reviewed critically and results interpreted cautiously.

For further information contact: Associate Professor David Wilson
National Centre in HIV Epidemiology and Clinical Research
Phone: +61 2 9385 0900
dp.wilson@unsw.edu.au

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HIV in Cambodia

The first case of HIV in Cambodia was detected in 1991. Cambodia's HIV epidemic is now a generalised one that has invaded diverse population groups. However, it is still largely driven by men visiting sex workers. There has been a strong commitment from the Cambodian government and external donors resulting in targeted public health interventions and a large scale-up of antiretroviral therapy (ART) access for HIV-infected people. Studies have indicated that declines in HIV trends in Cambodia are linked to behavioural changes in sex work: condom use between sex workers and clients increased to more than 90% by the mid-1990s compared to 30% in the late 1980s and the number of men visiting sex workers decreased from 20% to ~10% over the same period [1-6]. If the economic crisis affects these factors then there is reason to believe that epidemic trends could be reversed.

HIV in Papua New Guinea

The first notified case of HIV in Papua New Guinea (PNG) was in 1987. There was slow growth in the epidemic until 1994. PNG is now experiencing a steadily increasing HIV epidemic, which has been diagnosed in all PNG provinces. In PNG there are relatively high levels of transactional sex, partner exchange, mobility, physical and sexual violence, and gender inequality which have facilitated the spread of HIV. HIV is mainly transmitted heterosexually in PNG. Recent campaigns have led to increases in condom use and HIV testing. First-line ART has started to roll out to people living with HIV and AIDS in numerous provinces. Numerous HIV programs are newly established and may be relatively fragile to economic reductions.

Expected economic forecasts

Economies in Asia and the Pacific vary considerably from country to country. According to the Asian Development Outlook Database [9], economic growth in 2009 is expected to fall across the entire region. The decline in growth is expected to result in more than 35 million additional people in Asia trapped in extreme poverty in 2009.

Cambodia's economy

Cambodia's strong economic growth over the past few years has slowed markedly, liquidity is contracting and property prices have fallen. This has also resulted in a sharp decline in the construction industry, along with decreases in manufacturing production, the garment industry, and services. Cambodia has felt the effects of political instability in Thailand and has

also similarly experienced a noticeable decrease in tourist arrivals [17]. Because of its relatively small production base, concentration of exports and dependence on external flows in the market, the economy in Cambodia is particularly vulnerable to global financial perturbations. Cambodia's economy is still expected to contract in 2009 as the global economic slowdown will have a negative impact on exports. Five million Cambodians (35% of the population) are currently living in extreme poverty[9] and this will increase even further if the economy continues to slow.

PNG's economy

Strong commodity prices have underpinned growth in PNG's economy and in government revenue in recent years. But GDP growth is expected to decline as the global economic downturn leads to reductions in exports and commodity production, and weaker growth in incomes. Increases in unemployment could be expected, especially in the mining industry. Many people in PNG are farmers who produce mainly for their own consumption, with some cash-crop production of products such as cocoa, copra, and coffee. However, severe flooding in the Highlands region in early 2009 will damage coffee and tea production, which usually peaks between March and June. PNG has high unemployment, just over half of its adult population is literate, and an estimated 40% of its population are in poverty [9].

HIV-related factors that may change due to the economic crisis

Based on detailed discussions with key stakeholders and representatives from national HIV bodies in Cambodia and Papua New Guinea, as well as economists, behavioural researchers, and international policy and development experts, a list of major HIV-related risk factors were identified that may change as a result of the economic crisis (Table 1). This list is not exhaustive and there are other factors that are likely to be influenced by changes in the economy. However, these factors are thought to be the most important for potentially affecting HIV epidemics. These assumptions are aligned with a recent report by the Global Fund[19] that assessed vulnerabilities to HIV/AIDS due to the economy. The economic crisis may have direct effects on HIV/AIDS program resources and indirect effects by affecting the social and behavioural interactions of people.

Direct effects on program resources

The global economic crisis makes commitments of overseas development assistance more uncertain. In PNG in 2008, for example, only 13% of funding for the HIV response came from the Government of PNG. These funding proportions are similar in Cambodia. Further, the PNG Government's own funding for HIV in 2009 decreased by 53% compared with 2008. There is concern that the financial crisis may make aid flows more volatile. Some donors have signalled their intention to scale back

their aid budgets. The largest contributor to HIV programs in Cambodia is the Global Fund: they were unable to fund all of their approved projects in the recent funding round. An additional 10% reduction in existing grants has been requested, directly affecting funds for HIV programs. The major funder of HIV programs in PNG is AusAID; the Global Fund sources treatment and related clinical expenses.

It has been identified that reductions in program funds may lead to:

- *decreases in voluntary counselling and testing (VCT) services;*
- *decreases in education and prevention messages;*
- *changes in the availability of ART or slowed rate of increase in provision* (see Table 1).

It is expected that VCT services will not expand as quickly as otherwise hoped but should remain fairly steady. Testing rates may decrease and reduction in counselling and other prevention services may lead to a reduction in condom use. VCT services are less well established in PNG compared with Cambodia and are potentially more volatile.

If campaigns and educational activities reduce then condom use may decline and the rate of partner change may increase. Similar relative changes may be expected in Cambodia and PNG. It should be noted that money is probably not a large constraint for condoms in PNG, but distribution is relatively low.

In Cambodia there is almost universal access (~85%) to first-line ART for HIV-infected individuals who are eligible for treatment. In PNG provision of ART is currently scaling up; currently ~30% in need have access and the plan is to increase this to ~50-70% over 5 years. The majority of ART provision in both countries is funded by external sources. External economic pressures can have significant implications to treatment strategies and utilisation in both Cambodia and PNG.

Behavioural and social factors

The global economic crisis could have complex behavioural and social effects on heterogeneous groups of people. Key behavioural factors relevant to HIV epidemics that may be influenced by the economy include (Table 1):

- *increase in unemployment;*
- *change in intravenous drug use;*
- *change in alcohol consumption and the prevalence of violence;*
- *change in migration patterns.*

The economic downturn may lead to significant unemployment and in order to support themselves some unemployed individuals may turn to transactional sex work. It could be expected that the number of sex workers (supply) increases, but the number of men engaging their services (demand) decreases. In Cambodia it is anticipated that the total number of direct and indirect sex workers will increase, mainly due to a decline in the garment industry. This change could be expected to occur in the short-term. Reductions in tourist arrivals in

Cambodia will also decrease the demand for sex work. In PNG, a relatively large proportion of women engage in transactional sex of some form, particularly those not involved in other income-generating activities. As money is not always involved in transactional sex and it is more culturally acceptable in PNG, it is expected that transactional sex work could increase. However, only ~20% of adults are involved in formal employment. Newly unemployed individuals in PNG are likely to stay with their extended family in the short term and may turn to transactional sex work after 1-3 years.

With disposable income likely to decrease, use of intravenous drugs could be expected to decrease in numerous settings, including Cambodia. In PNG, intravenous drugs are not common.

Alcohol consumption is linked with decreased condom use and increased sexual assault which also tends to be unprotected. This is not thought to be a major problem in Cambodia. But in PNG, alcohol is commonly brewed at home and its consumption is expected to increase with higher unemployment.

Male migrant workers in Cambodia, particularly in the declining construction industry, are likely to return home to their regular female partners. In PNG, there is the rates of rural-to-urban migration have led to net population growth in urban settings. It is expected that increased unemployment will reduce the flow of people moving from rural to urban settings. People losing employment from the mining sector in PNG may go to towns for other employment. The expectation is for a net decrease in migration to urban areas.

A mathematical transmission model for HIV epidemics

Mathematical models are useful for understanding complex epidemics as they contain explicit mechanisms linking individual-level behaviours with population-level outcomes (e.g., incidence and prevalence). Models can be used to understand and forecast epidemics according to different scenarios due to interventions or changes in behaviour or programs.

A mathematical transmission model was developed to describe the HIV epidemics in Cambodia and PNG and to forecast expected epidemic trends in the future. The model describes the risk of HIV acquisition for six population subgroups: (1) males, (2) male clients of female sex workers (including other core groups of men), (3) men who have sex with men (and possibly women) (MSM), (4) injecting drug users (IDUs), (5) females, and (6) female sex workers (FSWs). The model includes heterogeneous interactions between all of these population groups to reflect the polymorphous nature of sexual behaviour and mixing in these settings[34]. The model is split into two components. Firstly, a risk equation is applied to each population subgroup to

estimate the overall risk of HIV acquisition per person per year. Secondly, a country-level dynamic model based on ordinary differential equations is used to forecast potential trends in HIV epidemics. A schematic diagram of the model is shown in Figure 1; this is replicated for urban and rural settings in PNG with migration between locations. Assumptions informing the models are presented in Table 2.

Figure 1: Schematic diagram of mathematical model

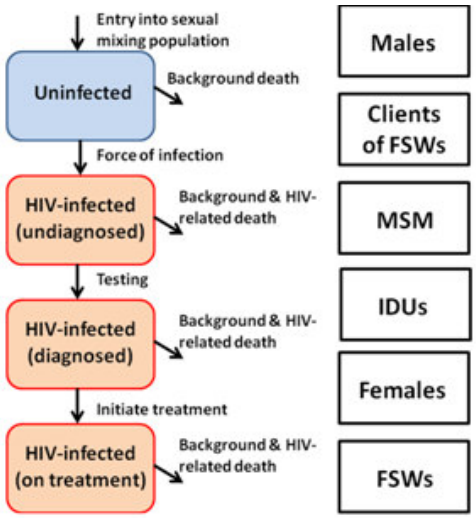


Table 1: Assumptions around possible change in HIV-related risk factors due to the economy (absolute changes are assumed for condom use and treatment uptake; others are relative changes)

Risk factor		**Potential change within 12 months**	
HIV programs		**Cambodia**	**PNG**
VCT services	Optimistic	HIV testing steady condom use steady	HIV testing steady condom use steady
	Intermediate	HIV testing rate ↓ 5% condom use ↓ 5%	HIV testing ↓ 7.5% condom use ↓ 7.5%
	Pessimistic	HIV testing rate↓ 10% condom use ↓ 10%	HIV testing ↓ 15% condom use ↓ 15%
Education and prevention	Optimistic	condom use steady partner change steady	condom use steady partner change steady
	Intermediate	condom use ↓ 5% partner change ↑ 3%	condom use ↓ 5% partner change ↑ 3%
	Pessimistic	condom use ↓ 10% partner change ↑ 5%	condom use ↓ 10% partner change ↑ 5%
Availability of antiretroviral therapy (coverage of diagnosed)	Optimistic	↑ 10% over 5 years	↑ 40% over 5 years
	Intermediate	↓ 2.5% over 5 years	↑ 25% over 5 years
	Pessimistic	↓ 5% over 5 years	↑ 10% over 5 years
Change in behaviour of people		**Cambodia**	**PNG**
Unemployment	Optimistic	no. sex workers steady demand for SW ↓ 10%	no. sex workers steady demand for SW steady
	Intermediate	no. sex workers ↑ 10% demand for SW ↓ 5%	no. sex workers ↑ 5% demand for SW ↑ 5%
	Pessimistic	no. sex workers ↑ 5% demand for SW steady	no. sex workers ↑ 10% demand for SW ↑ 10%
Intravenous drug use (Cambodia); Change in condom use and sexual activity due to alcohol consumption (PNG)	Optimistic	drug use ↓ 10%	condom use steady sex activity steady
	Intermediate	drug use ↓ 5%	condom use ↓ 10% sex activity ↑ 5%
	Pessimistic	drug use steady	condom use ↓ 20% sex activity ↑ 15%
Migration	Optimistic	regular partners steady	Steady, 15% in urban
	Intermediate	contact w/ partners ↑ 7.5%	14% in urban
	Pessimistic	contact w/ partners ↑ 15%	13% in urban

Table 2: Parameter assumptions informing the calibration of the HIV epidemic models

Parameter	Cambodia	Urban PNG	Rural PNG
Males			
Average number of regular sexual partners per year	0.58[a]	2[7, 8]	2[7, 8]
Average number of casual sexual partners per year	0.88 [a]	6.9[10-12]	9[a]
Condom use in casual partnerships with general females	30%[13-16]	10%[8]	10%[8]
Condom use in regular partnerships with general females	30%[13-16]	5%[10]	5%[a]
Prevalence of HIV	0.8%[33,34]	1%[18]	2%[18]
Prevalence of other sexually transmitted infections	1% [a]	5%[18, 20-22]	15.7%[21]
Male clients of female commercial sex workers			
Proportion of the population	6.5%[23]	26%	0%[a]
Number of visits to sex workers per year	62[24, 25]	18[7, 12, 26, 27]	N/A
Condom use in acts between clients and sex workers	95%[24]	60%[8, 10]	N/A
Prevalence of HIV	5% [a]	2%[18]	N/A
Prevalence of other sexually transmitted infections	1.5% [a]	1.5%[18, 20-22]	N/A
Men who have sex with men (MSM)			
Proportion of the population	1.5%[28-33]	3%[8, 10]	3%[8, 10]
Average number of male sexual partners per year	25[24, 35]	30[10, 12]	5[a]
Average number of female sexual partners per year	3[24, 35]	30[10, 12]	10[a]
Condom use in penetrative acts between MSM	80%[24, 35]	23%[10, 12, 18]	7.5%[a]
Condom use in penetrative acts between MSM and women	80%[24, 35]	50%[10, 12, 18]	7.5%[a]
Prevalence of HIV	7.5%[35 36]	2.5%[a]	3%[a]
Prevalence of other sexually transmitted infections	1.3%[24, 35]	20%[12]	20%[a]
Injecting drug users (IDUs)			
Proportion of the population	0.25%[38-41 43]	0%[a]	0%[a]
Average number of injecting partners per year	2[45]	N/A	
Average frequency of injecting per year	400[46-48]	N/A	
Percentage of injections that share injecting equipment	10%[45]	N/A	
Percentage of shared syringes that are cleaned before re-use	75%[51]	N/A	
Average number of regular sexual partnerships	0.25-0.75[16, 52, 53]	N/A	
Average number of contacts IDUs have with FSWs per year	2[16, 52]	N/A	
Prevalence of HIV	15%[51]	N/A	
Prevalence of other sexually transmitted infections	16%[51]	N/A	
Females (including those that engage in transactional sex)			
Prevalence of HIV	0.8%[54, 55]	1.5%[18]	2%[18]
Prevalence of other sexually transmitted infections	1%[56]	6%[20, 21]	15.7%[21]
Sexual behaviour parameters	Balance with male behavioural values		
Female commercial sex workers (FSWs)			
Proportion of the population	1.5%[57-59]	2%[26]	0%[a]
Average number of regular sexual partnerships	0.5[24, 35]	1.4[12, 26, 60]	N/A
Condom use in acts between FSWs and regular partners	85%[24, 61]	40%[8, 10]	N/A
Average number of casual sexual partnerships, outside sex work, that FSWs have per year	3.2[24, 35]	8.9[a]	N/A
Condom use in acts between FSWs and casual partners	80%[24, 35]	60%[18, 26]	N/A
Prevalence of HIV	15%[54]	15%[27, 62, 63]	N/A
Prevalence of other sexually transmitted infections	3.5%[56]	25%[27, 64]	N/A
Sexual activity between FSWs and clients	Balance with client behavioural values		

(a) Assumption. The population is split 1:1 between men and women for Cambodia and 1.2:1 for PNG[65]. The model also assumes the following. The presence of an STI increases HIV transmission risk by 4-5 fold[66-74]. A casual partnership involves 1 penetrative sex act and a regular partnership involves 75-100 acts per year. The baseline probability of HIV transmission per sexual act is 0.0008 for female-to-male transmission [75-79], 0.001 for male-to-female transmission [75-79], and 0.008 for male-to-male transmission [77, 80, 81]. Treatment reduces this rate by 95% [84]. HIV transmission risk using a contaminated needle/syringe is 0.01[82, 83]. The effectiveness of condoms is 90% [85-89] and cleaning of syringes has effectiveness of 75%[90-92]. People remain in the sexually mixing population for 45 years for PNG and 35 years for Cambodia, the rate of diagnosis of HIV-infection (i.e., testing rate) increased linearly from 0.14 (2003) to 0.5 (2009) for Cambodia, and is taken to be 0.2 for urban PNG and 0.12 for rural PNG. The time from infection to AIDS-related death for untreated HIV-infected individuals is 10 years [78, 93-96], and rate of death for treatment-eligible individuals on ART is 0.05 [97-104]. The rate at which diagnosed cases initiate therapy is taken to linearly increase from 0 in 2003 to 1.2 in 2009 for Cambodia. Before 2009, this rate is taken to be 0.25 and 0.125 for urban and rural PNG, respectively, and then increases to match treatment plans. The rate at which HIV-infected people on ART stop treatment is assumed to be 0.5.

Potential change in HIV risk

Based on the parameters and assumptions around potential changes due to the economic crisis, the risk of acquiring HIV infection per year was determined for each population subgroup. These calculations were translated into average incidence estimates per person for conditions before and after the impact of the economic crisis (Figures 2, 3).

In Cambodia, the factors that may be of greatest concern are:

- decreases in VCT and education.

In PNG, the factors that may be of greatest concern are:

- increases in violence and alcohol;
- decreases in ART roll out;
- decreases in VCT and education.

Thus, the economic effect on HIV treatment and prevention programs could have a greater impact than those related to increases in unemployment.

Figure 2: Change in HIV incident risk per person due to economic crisis in Cambodia (error bars denote incidence rates due to optimistic and pessimistic assumptions)

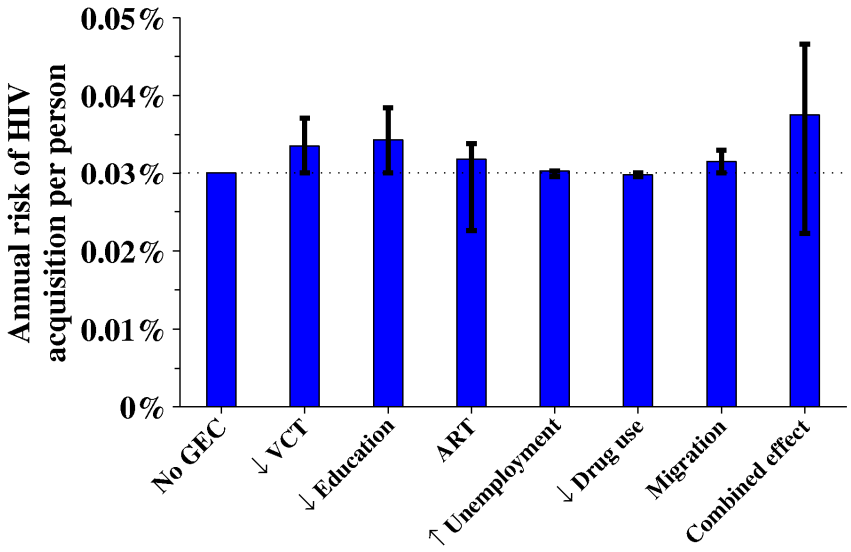
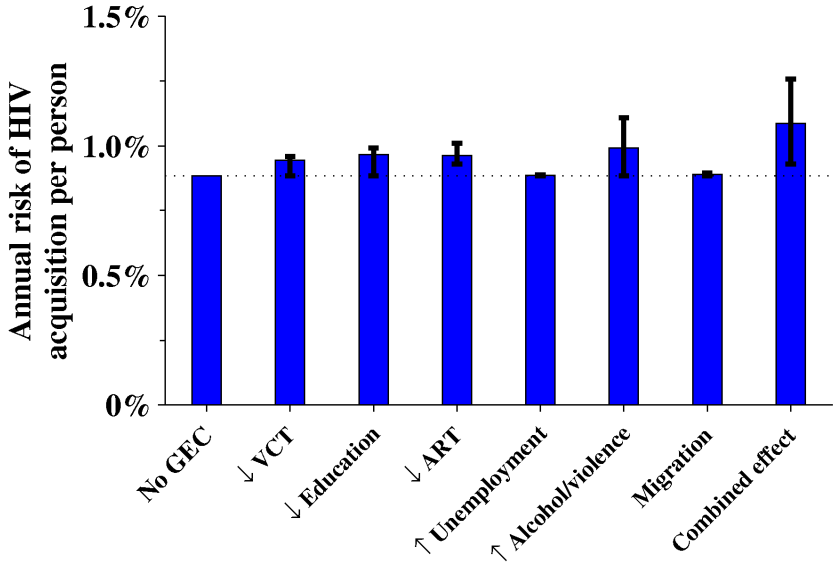
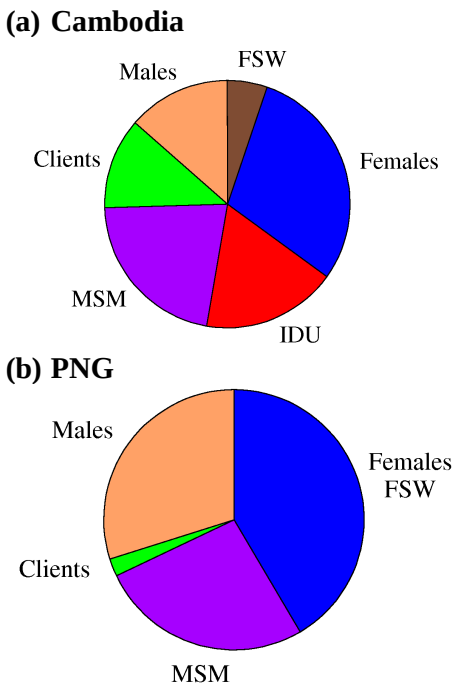


Figure 3: Change in HIV incident risk per person due to economic crisis in PNG (error bars denote incidence rates due to optimistic and pessimistic assumptions)



The proportions of all HIV infections attributable to each route of exposure and population subgroup are unlikely to change substantially due to the economic crisis since the change in risk per person is relatively small (the estimated proportions are illustrated in Figure 4). But the impact of potential changes due to the economy in certain population groups may influence the overall epidemic trends in terms of the number of new infections, diagnoses, and burden of HIV-related morbidities and mortalities.

Figure 4: Proportion of HIV cases by subgroup



Potential epidemiological impact of the economy on HIV epidemics

The annual risk of acquiring HIV infection per uninfected person was calculated as a weighted average across all population subgroups. This informed the 'force of infection' for a dynamic epidemic transmission model to describe the history of HIV epidemics. The mathematical model accurately reflected the HIV epidemics in Cambodia and in PNG, with regards to HIV notifications, prevalence, and treated cases (Figures 5, 6).

These models were used to forecast the expected trajectories of HIV epidemics over the next 3 years according to assumptions around changes to HIV programs or behaviour (Table 1). The expected impact of the economic crisis on HIV notifications and incident infections in Cambodia and PNG, according to intermediate assumptions regarding each potential scenario are presented in Figures 7, 8.

Figure 5: Mathematical model estimates (red curves) compared with Cambodian HIV data: (a) prevalence; (b) diagnoses; (c) number of people on ART

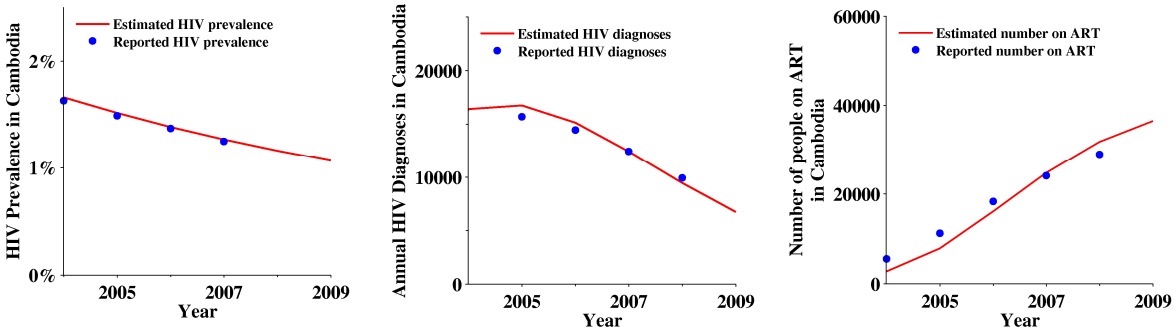


Figure 6: Mathematical model estimates (red curves) compared with PNG HIV data: (a) prevalence; (b) diagnoses; (c) number of people on ART

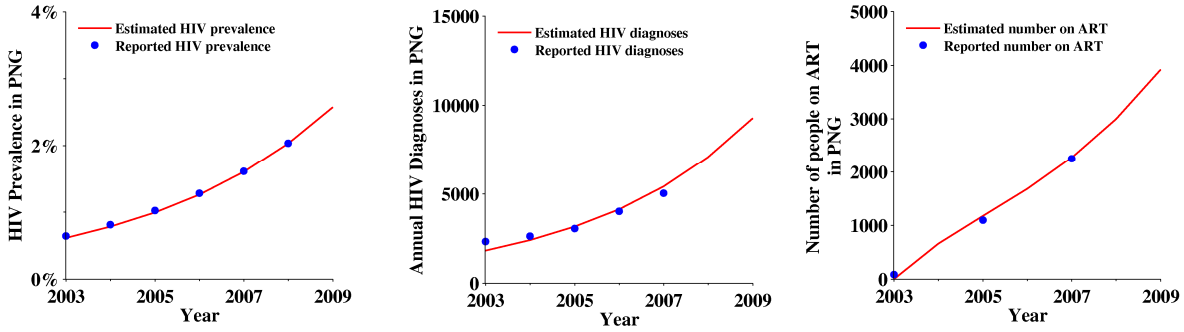
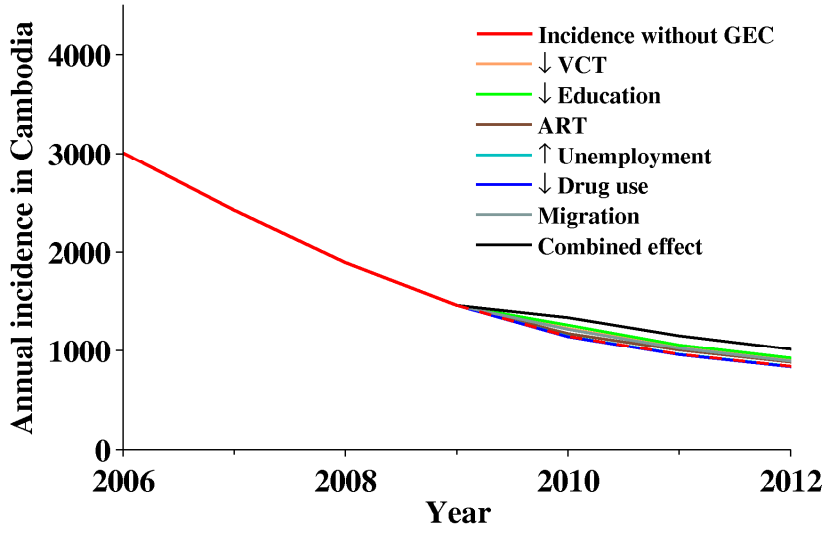


Figure 7: Model-based projections of (a) HIV incidence, (b) number of HIV diagnoses in Cambodia based on changes due to the economy

(a)



(b)

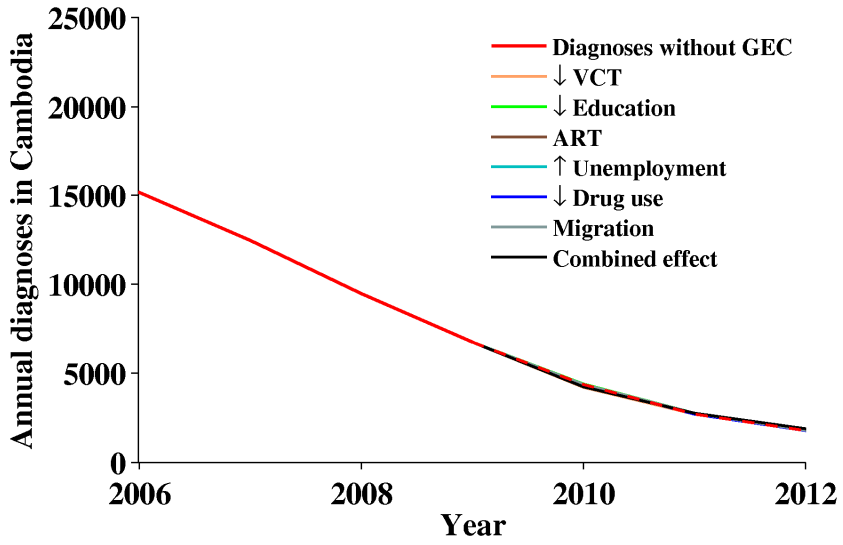
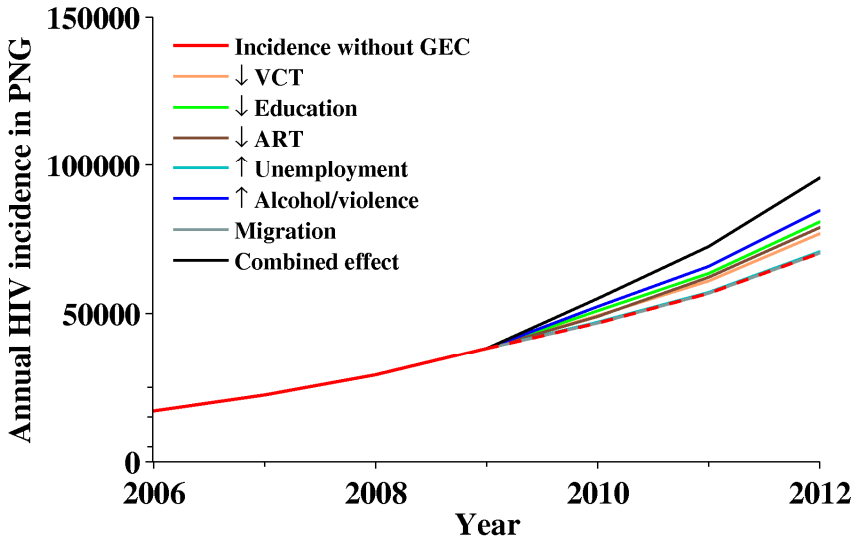
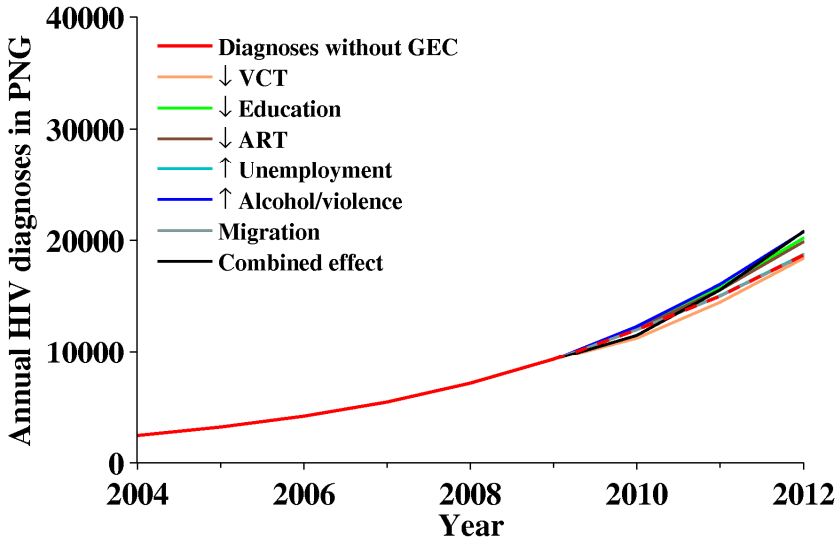


Figure 8: Model-based projections of (a) HIV incidence, (b) number of HIV diagnoses in PNG based on changes due to the economy

(a)



(b)



The model suggests that the economic crisis may have a relatively modest impact on the number of HIV cases in Cambodia and PNG. In Cambodia, the number of incident cases of HIV may increase slightly (by a maximum of approximately 15%), particularly if changes in VCT and education lead to reductions in HIV testing and condom use, and increases in partner change (Figure 7).

However, the actual numbers of diagnoses expected in Cambodia due to the economic crisis are unlikely to differ from expectations independent of the crisis (Figure 7). This is because of the relatively large pool of undiagnosed infections in Cambodia that are being diagnosed at a relatively constant rate even with some changes to VCT. Thus, the effect of the economy on the HIV epidemic in

Cambodia could be 'hidden' by the surveillance system. It is highly important, for monitoring the true extent of the epidemic, and for preventing new incident infections that VCT services are maintained, if not increased.

In contrast, both HIV incidence and diagnoses in PNG could be affected by the economic crisis (Figure 8). Intermediate assumptions around behaviour change associated with increases in violence and alcohol use could lead to an increase in incidence and new diagnoses of 20% and 11% respectively. Pessimistic assumptions (Table 1) could lead to a maximum increase of 46% and 24% in the number of HIV infections and diagnoses by 2012. However, moderate assumptions for most potential scenarios lead to relatively little change in overall infections and diagnoses (Figure 8). The combined effect of all scenarios may lead to increases in incidence and diagnoses of ~35% and 14%, respectively.

Perhaps surprisingly, the models predicted that a reduction in the coverage or rollout of ART will not cause a large increase in the number of HIV infections (Figures 2,3,7,8). But it could be expected that changes in the provision or ART may have a significant effect on the number of HIV/AIDS-related deaths. The models were used to estimate the relative change in the number of HIV/AIDS deaths with and without the potential effects of the economic crisis (see Figures 9,10). It was found that the coverage of ART over the next few years is the most important factor in determining the number of AIDS-related deaths in Cambodia. However, the total number of AIDS-related deaths in Cambodia is unlikely to be highly influenced by the economic crisis (Figure 9). In contrast, the number of AIDS-related deaths in PNG could potentially be highly affected by changes in conditions due to the economy (Figure 10).

Figure 9: Expected percentage change in the cumulative number of HIV/AIDS related deaths in Cambodia due to economic influences on key HIV-related factors. Error bars denote optimistic and pessimistic assumptions.

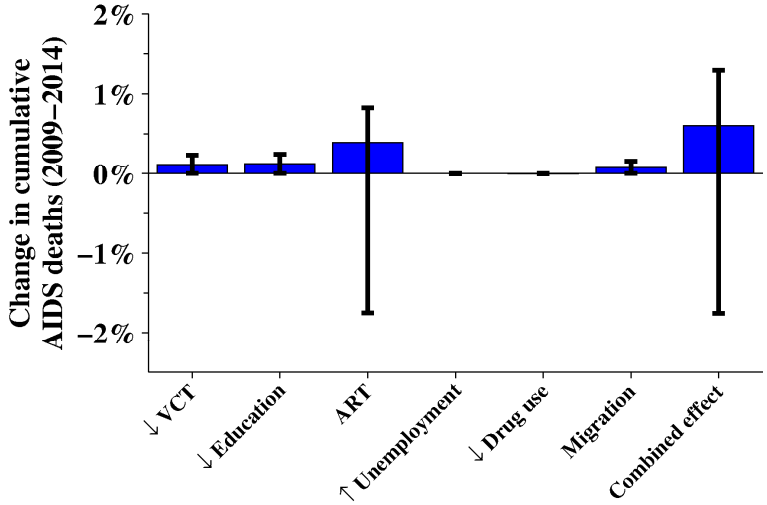
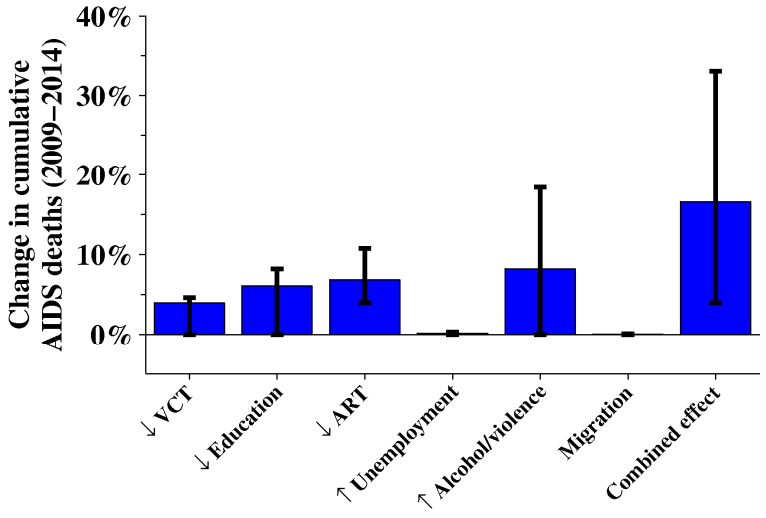


Figure 10: Expected percentage change in the cumulative number of HIV/AIDS related deaths in PNG due to economic influences on key HIV-related factors. Error bars denote optimistic and pessimistic assumptions.



Currently, availability of ART is relatively low in PNG but it is starting to scale-up. There are plans for large increases in the rollout of ART in the coming years. If the economy reduces this planned provision of ART then it could greatly affect the number of AIDS-related deaths (by ~15%, Figure 10). Other factors that may lead to increased incidence (such as decreases in condom use) could contribute to increases in AIDS-related deaths (Figure 10).

Conclusions

Although the current economic crisis has primarily been driven by global capital markets emanating from Western countries, it has progressed to affect real economies all around the world. The influence of changes in economy on social epidemiology is uncertain. It is widely believed that poverty tends to increase ones likelihood of taking sexual risks, particularly for women [34].

But in contrast, economic growth and increased wealth can be associated with the spread of HIV because greater disposable income produces greater opportunities for purchasing drugs and sex. However, it is also possible that people in crisis are more likely to take risks. There is an absence of reliable data to indicate the true extent of change in social determinants of HIV transmission due to economic variations, particularly in specific settings. More effective action is required to ascertain such behavioural shifts and then to respond in ways to prevent adverse consequences for HIV incidence, morbidities and mortalities.

This study identified key HIV-related risk factors that may change as a result of the economic crisis; pessimistic, intermediate, and optimistic scenarios were considered for each factor (based on consultancy with international and in-country experts and stakeholders). A mathematical model was used to simulate the expected epidemiological

effect in two distinct settings, namely, Cambodia and PNG. This was conducted to determine whether the economic crisis may potentially have a significantly adverse impact on HIV epidemics, a beneficial impact, or negligible effect. It was found that:

- decreases in HIV programs (such as VCT and ART rollout) will likely have a greater impact on the HIV epidemic than changes in unemployment (leading to greater sex work) and injecting drug use;
- HIV risk, incidence, and diagnoses are likely to be affected only modestly due to the economy;
- the epidemic profiles in established and emerging epidemics are not likely to alter significantly due to the economic crisis;
- securing the provision of ART is important for reducing HIV/AIDS-related deaths, particularly in PNG.

These findings are consistent with other reports on the potential impact of the global economic downturn on HIV/AIDS epidemics [19]. The current study highlights the high importance of maintaining HIV programs, particularly VCT services and the provision of ART. These programs are largely funded by external sources and small perturbations in their services can have noticeable affects on HIV epidemics in Cambodia and PNG. In Cambodia, VCT and ART are well-established. More costly second-line ART needs to increased in Cambodia as the rate of failure to first-line ART starts to increase. In PNG, both VCT services and first-line ART are relatively new initiatives and not very well-established. Any volatility in these programs could be largely detrimental to the HIV response in PNG. A major goal over the next 5-10 years in PNG is to strive toward universal treatment access and to increase access to VCT services.

Although the models developed in this study were calibrated to accurately reflect the unique epidemiology of Cambodia and PNG and were based on the best data available, they are caricatures of reality and cannot capture the full degree of complexity and heterogeneity that exists within population groups and transmission-related mixing, biology and virology, behaviour, and HIV programs. The models also do not consider treatment failure, drug resistance, and possible transmission of drug-resistant strains of HIV. More importantly, the results presented here are based on assumptions about what can potentially change due to the economic crisis (Table 1). This set of assumptions is the most crucial and largest limitation of this study, due to the difficulty in ascertaining the accuracy, or likelihood, of the assumptions within the environment of the global economic crisis. The results of this study should be critically reviewed in the context of the specific assumptions that informed them. However, the modelling results do suggest that prevention efforts must continue among the core groups in both settings (Figure 4) and among those most at

risk due to changes in the economy. But the trends in HIV epidemics are not expected to change markedly in the coming years.

This may indicate the relative independence of HIV risk from economic exigencies. However, the global crisis may have more impact on those living with HIV in terms of access to therapy (affording transport to the clinic etc) but maybe also in terms of food security and its affect on disease progression. This was not considered in the current model.

The last decade has been strong economically, enhancing international efforts to manage the HIV pandemic [37]. For example, funds have been intensified and mobilized for the large scale-up of ART in resource-constrained countries[42]. The majority of funds for HIV prevention, care and treatment in Cambodia and in PNG are externally funded from the Global Fund, international government development organisations (such as AusAID), and non-government organisations.

But the United Nations health-related targets of the Millennium Development Goals are unlikely to be achieved by 2015[44], and it is also doubtful that all commitments for HIV programs will be fully realized. Some donors have signalled their intention to scale back their aid budgets. Country offices have suggested that there are no indications of a decline in HIV funding for ART and the planned expansions should continue. However, any downturn in the funds available for the provisions of antiretroviral drugs may result in declining supplies, a smaller range of medications, particularly second and third line medications, and decreased availability to life-sustaining ART for the many people in need. This could also result in poorer treatment compliance, increased viral resistance and possibly transmission of resistant viral strains. HIV prevention efforts may also be unsustainable due to decreases in program funding. A judicious mix of funding sources and disbursement channels could be important for responding to HIV epidemics[49]. It is important that Governments take greater responsibility for funding HIV programs. This is particularly pertinent for PNG, where Government expenditure for HIV has decreased (despite an increasing epidemic).

This study demonstrated that even modest changes in behaviour due to current economic trends can lead to noticeable increases in the number of new HIV infections. In an age where HIV still infects more people than the rate of ART roll-out [50], it is still a state of emergency for responding to HIV/AIDS. Therefore, it is of very high importance that funding for HIV programs is maintained, if not increased, by external donors and governments, regardless of the economic conditions. However, this should be considered in the context that reducing poverty and unemployment, and increasing provision of food are probably the most demanding economic-related concerns to be overcome.

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National Centre in HIV Epidemiology and Clinical Research

For further information contact:
Associate Professor David Wilson
Phone: +61 2 9385 0900
dp.wilson@unsw.edu.au