



The impact of the transmission dynamics of the HIV/AIDS epidemic on sexual behaviour: A new hypothesis to explain recent increases in risk taking-behaviour among men who have sex with men

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Summary Increases in sexually transmitted infections and related high-risk behaviours have been reported among men who have sex with men (MSM) in industrialised countries when effective antiretroviral therapy against HIV infection has become widely available, in the mid-nineties. The reasons for these increases are not fully understood and often conflicting. Prevention fatigue, relapses to unsafe sex, as well as optimism toward the risk of developing AIDS among people living with HIV are not unique to the era of antiretroviral therapy (ART). This has led researchers to highlight the need to investigate other potential reasons that could explain the increase in high-risk taking following the ART introduction. We put forward the hypothesis that the change in the transmission dynamics of the HIV/AIDS epidemic before and after the introduction of ART has contributed to this change in high-risk behaviour.

It is suggested that a decline in sexual risk activities has occurred at the population-level following the initial spread of the HIV/AIDS epidemic because AIDS mortality and severe morbidity disproportionately depleted the pool of high-risk taking individuals. As a result, *non-volitional* changes may have occurred at the individual-level over time because the depletion of this pool of high-risk individuals made it more difficult for the remaining high-risk taking individuals to find partners to engage in risky sex with.

Following its introduction, ART has facilitated the differential replenishment of the pool of individuals willing to engage in high-risk taking behaviours because ART reduces AIDS mortality, and morbidity. Consequently, high-risk

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taking individuals who had previously reduced their level of risky sex non-volitionally (i.e., as a result of the reduced availability of high-risk partners) were able to resume their initial high-risk practices as the pool of high-risk taking individuals replenished over time. Thus, a fraction of the recently reported increase in high-risk sexual activities may be secondary to the fact that those MSM who were unable to engage in their desired high-risky sexual activities (because of reduced availability) are now able to revert to them as the availability of men willing to engage in risky sexual behaviours increases partly due to ART. Therefore, we suggest that a fraction of the changes in individual behaviour are non-volitional and can be explained by a change in "sexual partner availability" due to the transmission dynamics of HIV/AIDS before and after ART.

The hypothesis is formulated and explained using simple social network diagrams and the Theory of Planned Behaviour. We also discuss the implication of this hypothesis for HIV prevention.

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Introduction

Increases in some STI and related high-risk behaviours for STI and HIV/AIDS have been reported since the mid-nineties among men who have sex with men (MSM) in industrialised countries [1–6]. Reasons for the increases in risk behaviours are not entirely clear but prevention fatigue, lack of awareness among younger MSM and treatment optimism because ART became widely available have often been put forward as possible explanations [3,6–16]. However, most, if not all, of these reasons – including optimism toward the risk of developing AIDS among people living with HIV – have been identified in the early nineties and are therefore not unique to the ART era [17–21].

A recent meta-analytic review of 25 published studies on ART and sexual behaviour reported no significant overall effect between the use of ART or a reduced viral load and high-risk behaviours, but identified an overall positive association between positive beliefs about ART and high-risk behaviours [15]. The cross-sectional nature of the studies reviewed, however, makes it impossible to conclude on a causal relationship between optimism and high-risk behaviours. Optimism or beliefs may originate or intensify after someone engages in high-risk behaviours, acting as a posteriori self-justification [7]. Although some dimension of optimism was associated with high risk behaviour in cross sectional studies [15], other studies examining risk behaviours over time have shown that increases in risk are equally prevalent among the optimistic and the non-optimistic, thus questioning optimism as a driver of such change [9,10]. In the only longitudinal study available to date [16], the only belief associated with an increase in unprotected sex, among HIV negative individuals was: 'perceiving less HIV/AIDS threat'.

These conflicting results have led researchers to ask if the questions on optimism were properly formulated and to investigate if other reasons could

explain the increase in high-risk taking behaviours following the wide scale availability of ART therapy [7,9,10,12,16]. The cornerstone of the present hypothesis is that the change in the dynamics of the HIV/AIDS epidemic before and after the introduction of ART has contributed to this change in high-risk taking behaviours.

Summary of the hypothesis: The number counts!

It is suggested that a decline in sexual risk activities has occurred at the population-level (cross-sectionally at the aggregate level) following the initial spread of the HIV/AIDS epidemic because AIDS mortality and severe morbidity disproportionately depleted the pool of high-risk taking individuals (i.e., individuals with several sexual partners or/and most likely to engage in unprotected sexual activities) [22–26]. As a result, *non-volitional* changes may have occurred at the individual-level (longitudinally over time) because the depletion of this pool of high-risk taking individuals made it more difficult for the remaining high-risk individuals to find partners to engage in risky sex with which, as a consequence, also removes them from the pool of high-risk taking individuals [22].

Following its introduction, ART has facilitated the differential replenishment of the pool of individuals willing to engage in high-risk taking behaviours because ART reduces AIDS mortality, and morbidity [23]. As a consequence, high-risk taking individuals who had previously reduced their level of risky sex non-volitionally (i.e., as a result of the reduced availability of high-risk partners due to AIDS mortality and morbidity) were able to resume their initial high-risk practices as the pool of high-risk taking individuals replenished over time [22].

Thus, the decrease in risk taking sexual activities observed among MSM in the early eighties

[3,17–20,24] may in fact be partly attributable to a decrease in the availability of high-risk taking partners, partly due to AIDS mortality/morbidity – along other causes such as prevention. This may have deprived some MSM from the possibility to engage in their intended high-risk behaviours, with planned or chance encounters. On the other hand, a fraction of the recently reported increase in high-risk sexual activities may be secondary to the fact that those MSM who were unable to engage in their desired high-risky sexual activities (due to a lack of availability) are now able to revert to them as the availability of men willing to engage in risky sexual behaviours increases partly due to ART (and other factors discussed in Section Discussion). In other words, given the beneficial effects of ART, the number or pool of men with such high-risk taking intention is sustained or enhanced rather than reduced. In summary, the hypothesis proposes that a fraction of the changes in individual behaviour was non-volitional and can be explained by a change in “sexual partner availability” due to the transmission dynamics of HIV/AIDS before and after ART. Thus, from the point of view of the individual, predispositions (i.e., intention) to engage in unprotected sex may have remained constant, while opportunity has varied.

The rest of the paper is divided as follows. First, we explain more thoroughly how changes in individual sexual behaviours may be induced by the dynamics of HIV/AIDS at the level of social networks/communities. The concepts of individual volitional and non-volitional changes following a change in sexual partner availability are also introduced and illustrated using simple social network diagrams and a well known social cognitive theory, the Theory of Planned Behaviour (TPB) of Fishbein and Ajzen (1975) [27,28]. Finally, the difficulties to collect empirical evidence to support this hypothesis and the implication of this hypothesis for prevention is briefly outlined and discussed.

Volitional and non-volitional individual changes versus sexual environment changes

Potential changes in risk taking behaviours, as highlighted by mathematical modelling results [22,23], are summarised and illustrated with simple social network diagrams.

According to mathematical modelling, changes in risk taking sexual behaviours occur at the population level, during the natural course of the HIV/AIDS epidemic, because AIDS related mortality or

AIDS related illness (and cessation of sexual activity) disproportionately depletes the population of individuals with the riskiest sexual behaviours [23–26]. Further in the epidemic, when ART is made available to a large proportion of infected individuals, the inverse phenomenon occurs [23]. The availability of ART at the population level disproportionately favour the replenishment of the high-risk taking population by restoring the quality of life (QOL) of treated AIDS patients who then can return to being sexually active [29,30]. By reducing HIV related consequences, extending and favouring return to a more active sexual life and potentially slowing transmission due to reduced infectivity of HIV + individuals [31–34], ART also enables the replenishment of the high-risk taking population by in-migrants or new sexually active recruits entering a given scene [22,23]. These changes in the proportion of high-risk taking individuals, which occur at the population-level is referred to in the remaining of the text as changes in “sexual partner availability”.

Such changes in sexual partner availability (or in the sexual environment) will likely modify the structure of the sexual networks, which in return may impose some changes at the individual level. For example, when availability in high-risk taking sexual partners decreases (for the above mentioned reasons or others reasons such as prevention), those individuals who intend to engage in high-risk sexual activities may find it increasingly difficult to find partners to do so and may be left without much choice than having less sexual partners or less risky sex than first intended, or may have to explore novel ways of partner exchange and seeking. Therefore, changes at the population level may induce changes at the individual level [22].

Changes (increases or decreases) in availability can have different repercussions on individual sexual behaviours. Fig. 1 illustrates, with a simple example, different individual-level changes induced by changes in availability in a small sexual network of MSM. Typically the dots and the links represent individuals and mutual sexual relationships, respectively. The sexual network is formed of two components, a low and a high-risk one. Before the advent of AIDS (Panel (a)), each individual has exactly the level and type of sexual risk activity that they intend to and sexual behaviours are constant over time. In this situation, we say that the level of risky sex intended (noted with superscript i) is equal to the effective level of risk taking behaviour (superscript e). The low risk component is formed of three individuals who have one or two partners each and have protected sex. The high

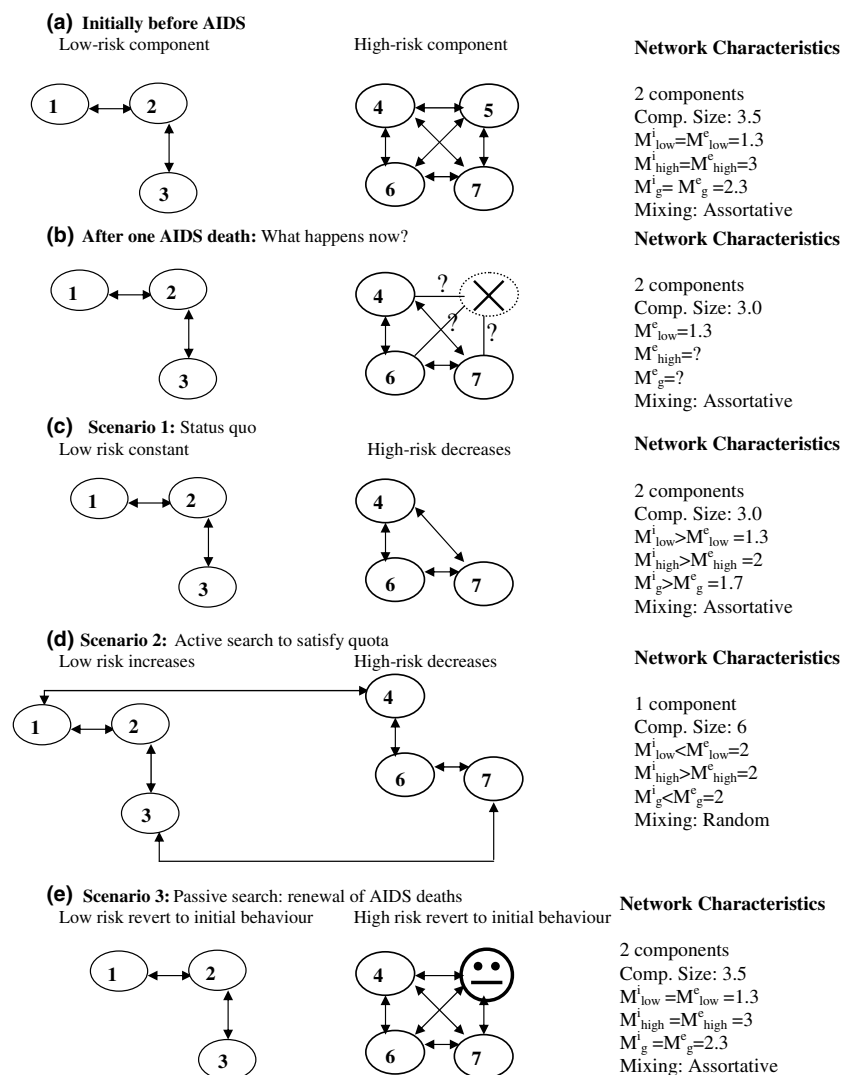


Figure 1 (a) Initially before AIDS. (b) After one AIDS death: what happens now? (c) Scenario 1: Status quo. (d) Scenario 2: active search to satisfy quota. (e) Scenario 3: passive search: renewal of AIDS deaths.

activity component is formed of four individuals who have three partners each and have unprotected sex exclusively. The average component size (Comp Size) is 3.5, the overall (M_g^e), low (M_{low}^e) and high-risk (M_{high}^e) average level of effective sexual activity are 2.3, 1.3 and 3, respectively. The mixing is assortative, that is partnerships are formed exclusively with members of their own risk taking groups (i.e., there are no link between components).

Following the death (circle with a cross) of individual no. 5 (Panel (b)) due to AIDS, individuals no. 4 and no. 7 are left short of one partner unless a new recruit joins the network component (Panel (e)). The average component size is reduced to three, but the low and high-risk effective average

in sexual activity and the mixing pattern is uncertain. It depends how each individual will react to this change in availability. If individuals no. 4 and 7 are unable to replace the lost partner (Panel (c)) they end up with fewer partners than intended and M_g^e , M_{low}^e and M_{high}^e decreases to 1.7, 1.3 and 2 respectively. Since the mixing remains assortative, all (100%) high-risk taking individuals still have unprotected sex exclusively.

“Intended” sexual behaviours (superscript i) refer to the behaviours that an individual wanted and was able to satisfy before changes in availability occurred (Panel (a)) and that they hope to maintain as much as possible as they do not have the intention to change behaviour. Effective sexual behaviours (superscript e) are the behaviours that are

observable over time, and that result after the effect of sexual environment constraints has been factored in. Note that in absence of variation in availability, intended behaviours are equal to the effective behaviours and remain unchanged over time (Panel (a)).

Alternatively, individuals no. 4 and no. 7 may eventually overlook their initial preference for unprotected sex with high-risk taking partners and may fulfil their needs by finding a third partner among people with lower risk taking behaviours (Panel (d)). This is possible if low risk taking individuals are unaware, for example, of the level of risk of the new partner. In this scenario, the network has one component of size 6. The network structure is altered since the mixing is no longer assortative. Here, all high-risk taking individuals have the same number of partners they originally wanted. However, individuals no. 1 and no. 3 now have more than intended and their effective overall sexual activity level is increased to 2. On the other hand, if the new low risk partner refuses to engage in risky sex, high-risk taking individuals will end up having less unprotected sex than intended. The last scenario (Panel (e)) occurs if, after a given period of time, the high-risk taking population can replenish to its initial state. In such case, higher risk taking individuals will be able to return to their initial pattern of intended sexual behaviour. It needs to be emphasized that individuals who return to their initial pattern of intended risky behaviour are different than those who relapse to risky sex. As opposed to those individuals who simply resume to high-risk sexual behaviour as availability increases, individuals who relapse have at least the intention to change their behaviour but have faced difficulties to translate their intentions into practice. The distinction is important otherwise relapse to risky sex will be over-estimated. In reality, however, the distinction between the two may not be crystal clear as behavioural changes may be partly explained by volitional as well as non-volitional reasons. These two dimensions are to some degree entangled.

In summary, volitional changes are those made as a result of a cognitive process, to fulfil a given "intended sexual agenda". Non-volitional changes are those that are imposed to an individual by a change in sexual partner availability or a change in the sexual environment and for which they have limited control. Because non-volitional behaviour changes are by definition not intended, they are expected to be more "fragile" (not permanent) and reversible than cognitive behaviour changes as long as intentions do not change. Of course, if intention changes for a variety of reasons such as

prevention, optimism and others, effective changes in behaviour will therefore be attributed to the overall changes in intention (volitional) and non-volitional changes, such as sexual partner availability.

In fact, non-volitional changes induced by variations in the sexual environment also depend on individual factors such as the sexual rigidity of individuals looking for new partners (individual seeking) and of those individuals belonging to the pool of partners being solicited (individual sought). Systematic changes in the sexual environment may therefore introduce a systematic change among individuals.

In our example in Fig. 1(d), the capacity of individuals with high-risk behaviours (no. 4 and no. 7) to have unprotected sex with a low risk taking individual depends on the dynamic involved in the new relationship, e.g., persuasion power of individuals no. 4 and no. 7 to engage in risky sex-sexual rigidity of individual seeking; ability of individuals no. 1 and no. 3 to resist and to negotiate safe sex (sexual rigidity of individual sought). If individual no. 1 concedes while negotiating safe sex, the partnership formed with no. 4 will result in unsafe sex.

Non-volitional changes in behaviour should occur when partners have discordant intentions. However, the extent to which changes in sexual partner availability will influence behaviour should depend on the magnitude of these changes, on the sexual rigidity (i.e., individual autonomy or individual self-efficacy) and on sexual and social networks of the individual seeking new partners.

Understandably, the complex interactions between different volitional and non-volitional determinants of behaviour are difficult to measure. It is therefore important to formulate the research questions precisely and to identify what needs to be measured and how it should be measured. In this regard, we more formally articulate our hypothesis using the Theory of Planned Behaviour (TPB) [27,28].

Theory of planned behaviour and the sexual environment/availability

Theory of planned behaviour

Many social cognitive theories allow for extra-individual influences, even if such influences are infrequently assessed in interventions and even surveys. Although individually centred, the TPB is useful to our current work because it offers the possibility to assess extra-individual influences at several

levels. The theory of planned behaviour (TPB, see Fig. 2(a)) is the dominant model for predicting and understanding health-related intentions and behaviour (see Armitage and Conner [35]; Godin and Kok, [36], for reviews). The TPB is an extension of Fishbein’s [37] theory of reasoned action (TRA) which proposed that the most immediate and important predictor of behaviour is the person’s decision or *intention* to perform it (e.g., ‘I intend to use a condom during sex’) [38]. According to the TRA, intention is determined by attitude and subjective norm. *Attitude* (ATB) refers to the per-

son’s overall evaluation of performing the behaviour (e.g., ‘Using a condom during sex would be good/bad’) whereas *subjective norm* (SN) refers to perceptions of social pressure from significant others to perform the behaviour (e.g., ‘Most people who are important to me think that I should use a condom during sex’). Norms may be drawn from society at large (e.g., the normative value of smoking in public), or from narrower samples such as peer groups (e.g., the mobilisation of gay men in the western world in the early 1980s in response to the AIDS epidemic which greatly contributed to

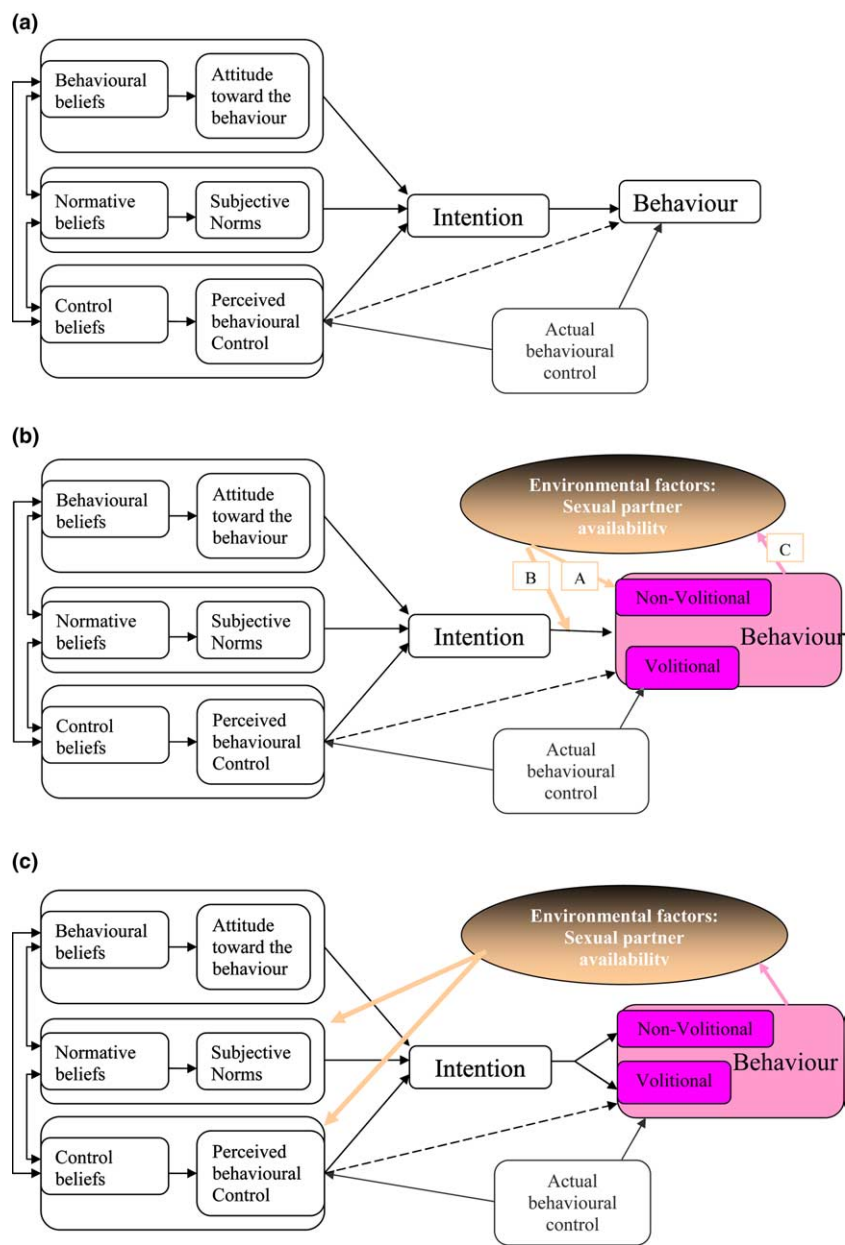


Figure 2 (a) No environment dimensions. (b) Direct influences of the environmental dimension. (c) Indirect influences of the environmental dimension.

changes social norms at large [39]). This approach has underpinned some of the HIV prevention efforts using influential peers to change norms and thus behaviour [40,41].

However, the TRA was designed only to predict volitional behaviours, i.e., behaviours over which the person has a good deal of control. To overcome this problem, Ajzen [38,42] “...added the construct of perceived behavioural control to the original theory of reasoned action when the work of Bandura and his associates made it clear that this construct was needed to deal with determinants of human behaviour that are not under complete volitional control” (Ajzen, 1998, p. 737) [43]. The reformulated model was called the theory of planned behaviour (TPB) and proposed that perceived behavioural control constitutes an additional predictor of intention alongside attitude and subjective norm. Perceived Behavioural Control refers to someone’s perception of her/his ability to perform a given behaviour. This perception depends on the *perceived power* (control) that an individual has over each *perceived factor* that may facilitate or impede the execution of such behaviour. Meta-analytic reviews indicate that perceived behavioural control contributes an increment of 5–13% of the variance in intention after TRA variables have been taken into account [35,36].

Potential routes of influence of sexual environment/availability

In recent years, a growing number of publications have suggested that the study of socio-structural factors should improve our understanding of the determinants of behaviour [44]. Socio-structural factors refer to features of the broader social context in which the person is located and is captured by assessment of resources and well being in respective communities. Thus, the social structure has the potential to affect action both through the individuals own position in the community and through the position of the community in a given society. It has been proposed that socio-structural variables could influence behaviour by three routes: cognitivist, interactionist or environmental determinist [45].

Direct influences of the sexual environment

To be consistent with the discussion in “Volitional and non-volitional individual changes versus sexual environment changes” and to highlight the influence of the sexual environment on behaviour at

the individual level, behaviour is depicted as the result of volitional and non-volitional contexts. In this view, the sexual environment/availability is considered an independent dimension which can influence behaviour directly via the Environmental “determinist” route or the Interactionist route (see Fig. 2(b)).

Environmental “determinist” route (A)

The Environmental “determinist” route suggests that population level factors directly dictate whether or not high-risk sexual behaviours are performed [45]. This is the route where sexual partner availability would have a direct influence on behaviour without being mediated by individuals’ behaviour-relevant thoughts (see Fig. 2(b) – A). This is a type of stimuli-response route, since a given behaviour is adopted because of the presence of a stimulus or in the present case an environmental condition. Thus, under this condition, an increase or a decrease in sexual partner availability would directly affect individual behaviour regardless of cognitions (i.e., intention and perceived behavioural control). In such a case, however, individuals still want the same level of risky sex than originally, but cannot achieve it in an environment of reduced availability. Therefore, non-volitional, as well as effective, behaviour changes ensue. This is the view proposed and illustrated in the network diagram presented in Fig. 1(a) and (c)–(e), since it is assumed that there is no change in the individual decision making process (i.e., intention is not changed).

Interactionist route (B)

Alternatively the “interactionist” route suggests that social structural factors interact with the initiation and pursuit of intended behavioural goals (Fig. 2(b) – B) [45]. The sexual environment affects the behavioural response by modulating the influence of intentions. Thus, if sexual partner availability for high-risk sexual behaviours decreases, individuals with high intentions to engage in this type of risk taking behaviours is strongly affected and are unable to act. In contrast, those with low intentions are not affected to the same extent by this decrease in sexual partner availability. Thus, non-volitional, and effective behaviour changes ensue mostly among those who intent to practice high-risk sexual behaviour.

The direction of the behavioural changes imposed by an increase or a decrease in sexual partner availability, i.e., whether effective behaviour will become more or less risky, will likely depend on the combined, but often conflicting, effects of the sexual rigidity of the individual seeking and

the individual sought (see “Volitional and non-volitional individual changes versus sexual environment changes”), as well as the availability of avenues that facilitates the fulfilment of these behavioural needs (such as the *Internet*). It also seems reasonable to assume that non-volitional behaviour changes will be less likely among individuals with high sexual rigidity and perceived behavioural control.

Example. To fully clarify how the environment can directly affect individual behaviour, let’s consider the following smoking example. To reduce smoking among youths, the federal Canadian government raised taxes on cigarettes by 550 per cent between 1982 and 1991 [46]. The idea was to make buying of cigarettes unaffordable to youths and to force them not to smoke despite their wishes to do so. Initially, the initiative appeared to work, since consumption rates plummeted. With direct analogy to our model, we could say that individuals reduced their cigarette consumption non-volitionally due to a decrease in the pool of affordable cigarettes. In “Volitional and non-volitional individual changes versus sexual environment changes”, we suggested that non-volitional changes are fragile and that individuals would be inclined to resume to their initial behaviour if lack of availability was not anymore a problem. This is indeed what happened in the early 1990s when smugglers, with the complicity of cigarette manufacturers and the use of Native reserves straddling the Canada-US border (used as a vehicle to avoid taxes), developed a plan and flood the Canadian market at cut-rate prices. It was estimated that under-priced contraband cigarettes constituted 40%–60% of the market. This was matched by an increase in cigarette smoking among youths, from 23% in 1991 to 29% in 1994; after which the government decided to reduce taxes [46].

Furthermore, studies on preparedness to share injecting equipment suggest that it is difficult to reduce needle sharing below a certain level even through efficient needle sharing programme [47]. Even in situations where drug injectors may have modified their “effective” behaviour in the direction of lower levels of reported sharing, a propensity (i.e., intention) to share may remain [48], which they concluded emphasize the need to continuously make clean needles available to injectors. These observations support our assumption that intention to engage in high-risk taking behaviour may remain despite apparent change in “effective” behaviour due to change in availability (in this context: availability of clean syringes).

As indicated on the TPB diagram (Fig. 2(b) – C), there is a feed back loop between effective behav-

our and sexual partner availability. Once behavioural changes occur, the sexual environment is also modified. Consequently, non-volitional behaviour changes continue to occur, so on, so forth, as long as sexual partner availability continues to change. If sexual partner availability starts increasing again after a decline, as for the introduction of ART following the spread of HIV/AIDS, then individuals are increasingly able to satisfy their intended behaviours and can slowly return to their initial level of risky sex, assuming that their initial intentions did not change. Obviously if non-volitional behaviours changes have greatly modified the structure of the sexual network, the reversion to original risk behaviours may happen over a long time scale or/and give rise to a higher risk network but with a modified configuration compared to the original one.

Indirect influences of the sexual environment

The social environment/availability could also influence behaviour less directly by influencing the cognitive process of individual’s decision making.

Cognitivist route

The “cognitivist” route is captured by the precepts of the TPB regarding external variables [27,28,35–38,42–45]. According to the TPB, social structure (i.e., sexual partner availability) only affects behaviour by affecting people’s cognitions and intention. This is a mediational account of the influence of the social structure. Thus, a given change in the sexual environment may influence behaviour, but by means of its influence on intention and/or perceived behavioural control (Fig. 2(c)). For example, a lower prevalence of a given behaviour in the social environment can affect subjective norm. As AIDS spreads in the population and the number of partners who engage in unprotected sex become lower, this can be viewed as the new norm. Also, the adoption of a given behaviour for non volitional reasons over a specific period of time may change one’s cognitions toward this behaviour. The new non-volitional behaviour, due to a mechanism of osmosis, self-justification, familiarisation or learning, may become positively valued, especially if individuals perceive no obvious external influence upon their behaviour [49]. This is what was hoped for in the smoking example presented earlier.

Finally, reduced or increased sexual partner availability may also affect perceived and actual behavioural control. As it becomes increasingly difficult or easy to find new partners, unsafe sexual risk behaviours decrease or increase, respectively.

If high-risk taking partners are extremely difficult to find, someone may have a low perception of control and in despair give up looking for such partners. In contrast, if high-risk taking partners become easier to find, the same person may be encouraged looking for such partners due to the increasing perception of control given the few successes. Because these changes are the results of a modification in the cognitive process, we qualify them as volitional.

Discussion

We argue that “sexual partner availability” is an important determinant of sexual behaviour. According to this hypothesis changes in sexual partner availability caused by the HIV/AIDS epidemic and the wide scale use of ART could partly explain changes in sexual behaviour in the early eighties and mid-nineties among MSM both at the population-level and individual level. Indeed, mechanisms that affect availability such as the use of the internet to find sexual partners, has been associated with increased high risk behaviour [10,50].

Obviously, other factors than AIDS mortality/morbidity or ART may influence sexual partner availability. In reality, cognitive changes have probably occurred as well, especially following extensive prevention strategies as in the early eighties in the MSM community [2,3,17–21]. Most prevention strategies aim at lowering the intention to have risky sex by altering its value and highlighting its negative health outcomes (e.g., attitude), by use of community role models to promote safe sex as the norm (i.e., subjective norm), and making available condoms and providing social supports through help lines, open forums, etc. (i.e., perceived behavioural control) [40,41]. These latter strategies also contribute to improve the ability of individuals to negotiate safe sex. Prevention aims to modify the cognitive process and to reduce risky sexual practice permanently.

It is reasonable to assume that individuals exposed to education messages and who hold positive predisposition to change are more malleable and more likely to engage in safer sex behaviours. Thus, as AIDS differential mortality/morbidity modifies sexual partner availability, safer sex efforts further contribute to modify sexual partner availability. As illustrated in panel (b) of Fig. 1, an increase in potential partners who insist on using condoms may result in forcing some individuals who did not want to engage in safe sexual practices to sometimes do so non-volitionally. As the sexual partner availabil-

ity continues to change over time even those who volitionally engage in safer sex behaviours most of the time may do so more frequently than intended. For example, following a prevention campaign some individuals may intend to decrease their number of casual partners from 10 to 5 per month, but due to a lack in sexual partner availability, they may end up having only three partners. Therefore changes in sexual partner availability may explain a fraction of the changes following a prevention programme. This also means that the effect of a prevention campaign may be exaggerated as some individuals may not have the level of risky sex that they intend to. Therefore, when ART enables the high-risk population to replenish, these individuals have the chance to gradually return to a high degree of sexual risk activity. Hopefully, prevention strategies should to a certain extent limit this effect and impose an upper constrain on the maximum that the re-bounce in risk taking behaviour can reach. This hypothesis makes a clear case for the importance of “positive prevention” i.e., a programme of HIV prevention linked to treatment and care and focussed on the HIV positive rather than the previous separation of prevention and care in approaching HIV and the relative lack of prevention provision targeted specifically at the HIV positive groups.

Other social events could also have modified sexual partner availability. For example, the closing of bathhouses in the US in the eighties has made it more difficult for MSM to have random unprotected sex [3,51]. On the other hand, increased opportunity can be a function of increased availability due to treatment but also of added facilities or technology such as the *Internet*-which enlarge the sexual network and increases sexual partner availability- as a source for partner seeking [10,52,53]. The recent observation that some MSM deliberately/volitionally intend to engage in unprotected anal intercourse (“bare-backing”) raise the question whether this phenomenon is new or not and whether bare-backers always existed but were unobserved or expressed a repressed intention given the more limited sexual environment [54,55].

In terms of prevention, it is important to realise that although risk taking sexual behaviour increases following the wide-scale use of ART, the risk of contracting HIV may not increase [5,29,31,32]. This is because ART reduces viral load and therefore the infectivity of treated HIV positives. However, the acquisition of other STI remains as risky as before—even in a context where HIV incidence would decline- since STI are not affected by ART [23,56].

The obvious challenge is to collect empirical data to support our hypothesis. First, it is necessary to demonstrate that the HIV/AIDS epidemic and the introduction of ART have modified sexual partner availability. We are aware of only two empirical studies that have addressed this issue and that have highlighted the impact of AIDS differential mortality on risk taking behaviour and syphilis over time [25,26]. Furthermore, model predictions are in agreement with available population-level data on trends in risk taking sexual behaviour and STD infection among MSM, in function of time, age, HIV and ART status [1–23]. Second, it is necessary to demonstrate that sexual partner availability influences behaviour. We gave examples to illustrate that the concept of non-volitional changes due to availability of a product (i.e., cigarette, clean needles). Anecdotal evidence also permits to suggest that this is also likely to be the case for sexual behaviour. For example, if we were to survey women who do not have a regular sexual partner, surely only a fraction of them would agree that this is a volitional situation. For example, in New York, the unbalanced male to female ratio makes it notably more difficult for women to find a desirable regular partner, whereas men may be more likely to engage in short term relationships [57–59]. Thirdly, to advance our specific hypothesis we need to show that changes in the sexual environment/availability at the beginning of the HIV epidemic and following ART introduction have been sufficient to induce significant non-volitional changes, that is they reached a threshold of influence. We are unaware of any studies looking at the influence of sexual partner availability on individual level changes in behaviour during the HIV/AIDS epidemic or the ART era. This is a complex concept to measure as behavioural determinants are often entangled. One way to more formally test the hypothesis would be to look at those who reduced their risk taking behaviours to find out if they really intended to change behaviour. Based on the TPB theoretical framework, such an analysis would look at variance in intentions versus variance in behaviour. As usual, there is a drawback as intention may change over time as a result of people incorporating environmental contingencies into their belief structure. That means we have to work even harder to make appropriate attributions about variance in intention (let alone behaviour).

Future prevention strategies would benefit from a better understanding of volitional and non-volitional changes. Unfortunately many studies of sexual risk taking behaviour have been individually oriented and have therefore been liable to underestimate the effect of the sexual environment/

availability on behaviour. Our hypothesis is important to understand the determinant of changes in risk taking sexual behaviour over time in order to optimally design prevention strategies. Indeed, prevention messages addressing individuals resuming previous risky sexual practices following an increase in availability of partners keen to engage in high-risk behaviours will likely be different than those really relapsing into risky sex. The former never wanted to change their behaviour and probably have a negative attitude toward prevention and unsafe sex while the latter want to be safe, hold a positive attitude toward safe sex but may, for a number of reasons (e.g., complex interaction with peers, power inequalities, cultural scripts, etc.) [60], have difficulties in maintaining safe behaviour. To get a better sense of the potential relapse to risky sex, it might be more appropriate to look at individuals who engage in safe sex despite their will, instead of looking at those who engage in unsafe sex despite their will as is usually done.

We believe that our hypothesis put some new light in the factors related to the risk taking behaviours and that it is useful to better understand recent increasing trends in STD and risky behaviours among men who have sex with men (MSM).

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