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AN ACTUARIAL ANALYSIS OF THE AIDS EPIDEMIC AS IT AFFECTS HETEROSEXUALS

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ABSTRACT

It is well documented that Acquired Immunodeficiency Syndrome (AIDS) can be transmitted by penile-vaginal sexual intercourse and that some heterosexuals have been infected with the AIDS virus in that manner. However, it also is well documented that the efficiency of such transmission is very low and that, except for intravenous (IV) drug users, only a very small percentage of heterosexuals are infected.

This paper first reviews the current state of the AIDS epidemic. Then it looks at the classification process used by the Centers for Disease Control to allocate cases to the various risk classifications, particularly for cases determined to be transmitted by heterosexual contact. It then examines the implications of the AIDS epidemic for the sexual lifestyle of heterosexuals.

The paper shows that for most heterosexuals, the risk of becoming infected with the AIDS virus by sexual contact is insignificant compared with many other risks of life. It also shows that emphasis on heterosexual monogamy and the use of condoms will have little impact on the epidemic.

Next, the paper examines the public misunderstandings about the AIDS epidemic. It shows that these misunderstandings have led to discrimination against people infected with the AIDS virus and to unwise legislation. It demonstrates that, for many, the fear of AIDS may present more of a mortality risk than AIDS itself.

Finally, the paper presents some recommendations for AIDS education and other perspectives on the epidemic for non-drug-using heterosexuals.

I. INTRODUCTION AND SUMMARY OF CONCLUSIONS

It is well documented that Acquired Immunodeficiency Syndrome (AIDS) can be transmitted by penile-vaginal sexual intercourse and that some heterosexuals have been infected with the human immunodeficiency virus (HIV) in that manner. However, it also is well documented that the efficiency of such transmission generally is very low, particularly from female-to-male.

After reviewing the current state of the AIDS epidemic, this paper examines the implications of the low efficiency of the transmission of HIV by

heterosexual contact, particularly for the sexual lifestyle of heterosexuals. It also briefly reviews some of the misinformation that has influenced the attitude of heterosexuals about AIDS. Finally, it presents some recommendations for changes in public policy on AIDS education and prevention.

Although the AIDS epidemic is worldwide, all data and commentary here relate only to the AIDS epidemic in the U.S. unless specifically stated otherwise.

The principal results and key findings are as follows.

A. Background: The Current State of the AIDS Epidemic

Data reported to the Centers for Disease Control (CDC) through December 31, 1991 indicate the following:

1. Based on date of diagnosis, the AIDS epidemic appears to have leveled off in 1990 at between 47,000 and 50,000 new cases annually. In that year, 43,352 cases were reported to the CDC. The number of cases reported in 1991 rose by 5 percent, to 45,506.
2. The number of cases in 1990 is well below the projections made by various actuaries, which ranged from 55,000 to 70,000. For 1991, the gap is much larger, because the epidemic had been projected to continue to grow until the mid-1990s, with the annual number of new cases estimated to reach between 90,000 and 120,000 at that time.
3. Since 1987, the number of reported cases has been increasing in part because in 1987 the CDC expanded the definition of AIDS. The proportion of cases being reported under the new definition has been gradually increasing, as the reporting process improved.
4. The number of heterosexually transmitted cases is still increasing, but is showing evidence of leveling off in the near future. Because there are so few cases, no definite conclusions can be drawn; however, it is clear that the number of cases classified as transmitted by heterosexual contact will continue to be low.

In analyzing the CDC data, the following points must be considered:

1. Based on adult/adolescent AIDS cases reported through December 31, 1991, 87 percent were from male homosexual/bisexual contact, IV drug use, or a combination of the two. Only 5 percent were classified as from heterosexual contact. For men, an even higher proportion of cases (91 percent) were from either homosexual/bisexual contact or IV drug use.
2. Many homosexual men and IV drug users have attempted to conceal their lifestyle. Studies have shown that some homosexual or IV-drug-using men have been successful in doing so even after developing AIDS and being questioned by medical personnel. Although there is evidence that some female-to-male transmission occurs, if less than 2 percent of such men were successful in this effort, it would account for *all* the male cases being reported as heterosexually transmitted.

3. For women, 51 percent of the reported AIDS cases have been classified as from IV drug use, and 31 percent have been attributed to heterosexual transmission. Of these, 69 percent were classified as sexual contact with an IV drug user. While it seems clear that a portion of the women categorized as having developed AIDS from sexual contact did in fact get it that way, it also is likely that some portion of those who allegedly developed it from sexual contact with IV drug users were IV drug users themselves, and may have become infected through IV drug use rather than heterosexual contact. It also is likely that some of those who become infected with HIV from sexual contact did so by anal, rather than vaginal, sex.

B. Analysis of the Implications of the Low Efficiency of Transmission of HIV by Heterosexual Intercourse

The transmission of HIV by heterosexual intercourse has been demonstrated to be possible, both male-to-female [30] and female-to-male [36]; however, unlike most other sexually transmitted diseases (STD), it is extremely inefficient [19], particularly female-to-male. HIV also can be transmitted by other means, most notably by sharing IV drug needles and by blood transfusions with infected blood. The implications of these facts are not always apparent; they include the following:

1. Assuming that the likelihood of transmission per sexual act does not change with the number of sexual acts with a given partner, the added risk from engaging in sexual activity with multiple partners, as compared with the same number of acts with the same partner, is very small. For 100 such acts, it is only 3 percent to 6 percent more risky to have multiple partners (assuming the same level of infectivity and risk that partner is HIV+).
2. The likelihood of transmission might increase as the number of sexual acts with the same HIV+ partner increases for several reasons, including less sexual arousal and therefore less protective vaginal lubrication, less use of condoms, possible increased experimentation with anal sex as a means of bringing variety into an existing sexual relationship, and a possible (but unproven) cumulative effect of exposure to HIV.
3. For heterosexuals, if the likelihood of transmission increases only slightly with repeated sexual activity with the same partner, risk levels will actually *decrease* for sexual activity with multiple partners, as compared with the same amount of activity with one partner.
4. Choice of sexual partners is very important. For a woman whose sexual partners are not chosen from within the IV drug community, the risk is remote. However, if her sexual partners generally are IV drug users who may be expected to have a high incidence of HIV infection, the risk increases by several orders of magnitude and becomes significant, particularly if she has repeated sexual activity with such persons.
5. The woman who generally chooses sexual partners who are not needle-sharing IV

drug users should not be unduly concerned about the possibility that she might on some occasion have sexual activity with someone who had done IV drugs. It is unlikely she would be involved with an IV drug user who shares needles, and a single act of sex with an infected partner is highly unlikely to transmit HIV unless the women has some abnormality such as previous serious STDs or vaginal bleeding.

6. A person should not be concerned about who his or her sexual partners had been with previously, unless it appeared that the partner had had a regular sexual relationship with someone in a high-risk group, or who was known to be HIV+. Tertiary transmission cases have been rare.
7. Urging heterosexuals to use condoms will have virtually no effect on the overall progress of the epidemic, will do little to reduce the spread of heterosexually transmitted AIDS, and in some situations may actually increase the likelihood of transmission of HIV, for the following reasons:
   - Most transmission of HIV is from homosexual contact or from IV drug use. Urging the use of condoms for heterosexual contact obviously will have no effect on such transmissions.
   - The greatest incidence of condom use is for casual sex. However, it is estimated that 85 percent to 90 percent of heterosexually transmitted AIDS cases result from sexual activity with one's primary partner, where a condom is less likely to be used.
   - Condoms are less likely to be used by the teenagers and others who are the most likely to be exposed to HIV. They are more likely to be used by the more socially responsible segments of the population, for whom the risks are so low that the likelihood of infection is remote in any event.
   - The use of a condom may encourage people to engage in sexual activity with high-risk persons whom they otherwise might avoid. Because condoms only reduce, but do not eliminate, the possibility of HIV transmission, the added risk from sexual activity with high-risk partners may exceed the reduction in risk from condom usage.

C. Public Concerns about the Risks of AIDS for Heterosexuals and Their Effect on Lifestyles and Public Policy

1. In many instances the media have grossly distorted the risks of heterosexually transmitted AIDS, for example, the extent to which the epidemic would spread to heterosexuals, the efficiency of transmission, overemphasis on isolated incidents of no real significance except to those involved, presentation of data in a biased and misleading manner, and mistakes of fact.
2. There are serious public misperceptions about the disease and the likelihood of acquiring it under various circumstances:
   - Many people believe that they can become infected from casual contact with someone with AIDS.

- Most people do not realize how rare the disease is except among homosexual men and IV drug users.
- Few people understand the implications of the low efficiency of transmission by heterosexual contact.

As a result, there have been thousands of instances of unfair and unnecessary discrimination against people known or even suspected to be HIV+.

3. Little attempt has been made by those responsible for AIDS education to consider all the risks of life and to put the AIDS risk in perspective. As a result, not only has undue fear been created in the minds of the public, but also in some instances the negative side effects of the AIDS education may exceed the small reduction in risk levels that AIDS education could achieve.
4. Mortality varies considerably by marital status. Except for males under age 20, married people have substantially lower mortality rates than others. Based on such rates, delaying marriage by only a couple of days causes an added mortality risk of one-in-a-million. The risk of HIV infection from sexual activity for most heterosexuals not regularly involved with IV drug users is on the order of magnitude of one-in-a-million or less. If the fear of AIDS causes the typical heterosexual to avoid or delay the development of relationships with the opposite sex, and thereby delays either the time of marriage or reduces the probability of marriage, the added mortality risk may far exceed the benefit of avoiding the risk of HIV infection.
5. Except for black females, the risk of HIV infection from heterosexual contact for teenagers is small compared with other mortality risks, even cancer and heart disease.

D. Conclusion and Recommendations

1. While the risk of AIDS should not be ignored by those sexually involved with persons in high-risk groups, for most heterosexuals allowing the fear of AIDS to impair the enjoyment of a healthy sex life and the development of meaningful relationships will be more costly in terms of human mortality and morbidity than the risk of AIDS.
2. AIDS education for heterosexuals should be better focused. Instead of emphasizing abstinence, monogamy, and the use of condoms, education should focus on two points:
   - Avoidance of sexual activity with known or suspected IV drug users (and of course with persons known to be HIV+). The *choice* of sexual partners is far more important than reducing the number of partners or using condoms.
   - Prompt treatment of any other STDs, because of the correlation between STDs and susceptibility to HIV infection.

   The author believes that this approach would have a significant chance of being understood and followed by most of those who might be at risk of HIV infection, and could prevent a significant proportion of heterosexually transmitted HIV infections—something that is not possible using present education and prevention approaches.

3. Health-care officials and others also need to be better educated about what needs (and does not need) to be done to control the epidemic.
4. The public should be better educated about risk levels, both for AIDS and for other risks in life. It will never be possible to eliminate risk. To try to do so, while ignoring the secondary effects, is counterproductive and merely takes the focus away from the real problems of our society.
5. We must recognize and publicize that AIDS never is going to become widespread throughout the general population, so long as reasonable health standards are followed.

II. BACKGROUND: THE CURRENT STATE OF THE AIDS EPIDEMIC

In analyzing the implications of the AIDS epidemic for heterosexuals, the first step is to examine the overall state of the epidemic. If it were to show no sign of slowing its spread, the need for drastic measures to control it obviously would be more urgent than if the incidence of new cases were leveling off.

Some of the more significant issues to consider in examining the data on the AIDS epidemic are as follows:

1. Because of the substantial period between HIV infection and the development of clinical AIDS, a look at the number of reported AIDS cases is not sufficient to determine whether the number of persons becoming infected is declining. However, a truly accurate estimate of the number of new HIV infections is not possible, and in any event the public perception of the AIDS epidemic is going to be based on the number of new AIDS cases actually reported, not on the number of estimated new HIV infections.
2. Even when a person develops AIDS, there is a delay between the time that he or she is diagnosed as having AIDS and the time the case is actually reported to the CDC. As the CDC data indicate, this delay can be significant. Even a full year after diagnosis, only about 75 percent of the cases have found their way into the CDC data bank.
3. The definition of AIDS has been expanded twice, and is about to be expanded for the third time, to reflect increased knowledge about the disease. According to the CDC, the first of these changes, in June 1985, caused only a 3 to 4 percent increase in the reported incidence of AIDS; however, the second, in August 1987, has sharply increased the number of reported cases. As a result, any analysis of the progress of the epidemic during the past three years that did not take into account the 1987 change could overstate the underlying trend in the number of new AIDS cases. (The third expansion in the definition will not become effective until sometime in 1992, so we cannot examine its effect on the number of reported AIDS cases. However, it will have little effect on the total number of cases reported, but rather will simply accelerate the reporting of such cases.)

4. Finally, the progress of the epidemic varies according to risk group. For male homosexuals, the number of new HIV infections is believed to have peaked several years ago. The number of new HIV infections among IV drug users and non-IV-drug-using heterosexuals also probably has peaked, although more recently. Any look at the progress of the epidemic must examine the risk groups separately, as well as in total.

A. The Current State of the AIDS Epidemic

To examine the progress of the epidemic in total, let us first look at the number of cases reported to the CDC by quarter, both in total and for the pre-1987 definition cases only. Table 1 shows such a comparison from 1988 through 1991.

TABLE 1

AIDS CASES BY REPORTING DATE

		All Cases		Pre-1987 Definition Only	
Year	Quarter	Number of Cases	Moving Average for Most Recent 3 Quarters	Number of Cases	Moving Average for Most Recent 3 Quarters
1988..	1st	7,597		5,509	
	2nd	8,117		5,878	
	3rd	8,449	8,054	6,091	5,826
	4th	7,916	8,161	5,543	5,837
1989..	1st	8,215	8,193	5,801	5,812
	2nd	9,198	8,443	6,448	5,931
	3rd	8,953	8,789	6,251	6,167
	4th	8,864	9,005	6,023	6,241
1990..	1st	10,647	9,488	7,250	6,508
	2nd	11,478	10,330	7,833	7,035
	3rd	12,292	11,472	8,138	7,740
	4th	8,922	10,897	5,695	7,222
1991..	1st	10,803	10,672	7,134	6,989
	2nd	10,958	10,228	6,887	6,572
	3rd	12,884	11,548	8,410	7,477
	4th	10,674	11,505	6,739	7,345

Table 1 shows that, on the basis of reporting date, the number of cases being reported has leveled off significantly. Based on the total number of cases and using a nine-month moving average to smooth out fluctuations, there was a drop of 11 percent from the peak of 11,472 in the third quarter of 1990 to 10,228 in the second quarter of 1991, followed by a return to the higher level. If only pre-1987 definition cases are used, the corresponding decrease was 15 percent, and the level of 7,740 in the third quarter of 1990 was not reached for any quarter in 1991.

A better way to examine the trend is to study the progress of cases by date of diagnosis, but to do this, we must make allowance for cases diagnosed but not yet reported. This was done based on cases reported to the CDC through December 31, 1990 in my article in the July/August 1991 *Contingencies* [34]. In it, lag factors were developed to allow for diagnosed but unreported cases. It was then estimated that the number of diagnosed cases peaked at 12,464 in the first quarter of 1990. As of this writing, the cases reported in 1991 have not been analyzed by date of diagnosis. However, total reported cases increased only 5 percent from 1990, and cases meeting only the pre-1987 definition increased only 1 percent. This further suggests that the epidemic is leveling off.

The revision of the definition of AIDS that is supposed to take place some time in 1992 will include HIV-infected people with CD4 counts of 200 or less. Low CD4 counts indicate susceptibility to opportunistic infection. According to the CDC, preliminary data indicate that "the expanded definition will initially capture a substantial number of persons somewhat earlier in their course of HIV infection but will have a much smaller effect in increasing the cumulative number of AIDS cases" [7]. As a result, when the new definition becomes effective, it will be difficult to examine the trend in new AIDS cases until the effect of the changed definition has worked itself out, unless some special provision is made in the reporting process. This could take several years.

For AIDS cases classified as heterosexual contact, the epidemic is slowing but has not yet peaked. In 1990, there were 2,799 cases classified as heterosexual contact, an increase of 39 percent from the 2,010 reported in 1989. However, the 3,387 cases reported in 1991 represented an increase of only 21 percent from the number reported in 1990.

It is not surprising that the heterosexual contact cases have not yet reached a maximum. Most such cases arise from sexual activity with an IV drug user. The initial surge of AIDS cases came from homosexuals; only more recently has the disease spread through the IV drug community. The sexual partners of IV drug users, having become infected later in the epidemic, also are contracting AIDS later. However, as shown later, tertiary infections are rare, and so the number of heterosexually transmitted cases should remain low and closely related to, but lagging behind, the incidence of AIDS among IV drug users.

B. Comparison with Earlier Projections of the AIDS Epidemic

If, as the above data indicate, the epidemic has peaked, the actual number of cases that will be diagnosed in the years ahead may be far less than estimated by the various experts, who generally had predicted that the epidemic would peak in the mid-1990s and at a much higher level. Table 2 compares the predicted number of AIDS cases based on several projections by actuaries. In each case, the "middle projections" made by the respective authors were used.

TABLE 2

PROJECTED ANNUAL AIDS CASES

	Projected Number of New AIDS Cases		
Year	Plumley [33]	Cowell and Hoskins [13]	Report of Society of Actuaries Committee on HIV Research [39]
1990	70,724	57,807	55,433
1991	87,055	76,204	64,644
1992	101,158	96,487	72,873
1993	111,596	117,307	79,765
1994	117,680	136,681	85,105
1995	119,749	152,324	88,815
1996	118,081	162,613	90,905
1997	113,881	166,872	91,470
1998	108,126	165,155	90,670
1999	101,829	158,143	88,710
2000	95,381	146,971	85,833

The 1990 figures in Table 2 compare with 43,352 cases actually reported to the CDC in that year, and 47,000 to 50,000 (depending on the lag factors used) estimated to have been diagnosed. The 1991 figures compare with the 45,506 cases actually reported to the CDC in that year.

A more optimistic view of the future of the epidemic was taken by Bregman and Langmuir in their March 1990 article in the *Journal of the American Medical Association*, "Farr's Law Applied to AIDS Projections" [4]. In essence, Farr's Law states that in large epidemics, the incidence of new cases tends to rise to a crest and then fall in a manner such that the entire curve forms the shape approximately described by a normal curve. Bregman and Langmuir used Farr's Law to project the number of AIDS cases, using only those cases meeting the pre-1987 definition. Their projection showed that, based on date of diagnosis, the epidemic peaked in 1988 and should decline rapidly during the 1990s.

An examination of subsequent data indicates that their short-term projections were too optimistic, principally because they underestimated the magnitude of diagnosed but unreported cases. For the same reason, their longer-term projections are likely to be too low; however, the principle of Farr's Law still suggests that there may be a sharp decline in new AIDS cases in the years ahead, though at a later date than projected by Bregman and Langmuir.

The year 1992 may see a substantial increase in reported AIDS cases because of the latest revision in the CDC definition of AIDS. Otherwise, it appears that all of the actuarial projections are far too high. The pleasant implications of this are beyond the scope of this paper, but should be welcomed by health-care providers, insurance companies, public health officials, and many others who had been bracing for a continuing increase in the volume of new AIDS patients insurance claims through the mid-1990s.

C. The Classification of Cases by the CDC

Because HIV is transmitted in certain specific ways and therefore affects certain groups of people far more than others, it is important to classify cases according to the manner in which the person became infected. At present, the CDC uses the following exposure categories for adults and adolescents, shown here with cases reported through December 31, 1991:

Male homosexual/bisexual contact	118,362 (58%)
IV drug use (female and heterosexual male)	45,753 (23%)
Male homosexual/bisexual contact and IV drug use	13,135 (6%)
Hemophilia/coagulation disorder	1,713 (1%)
Heterosexual contact with a person with, or at increased risk for, HIV infection	9,413 (5%)
Born in Pattern II country	2,523 (1%)
Receipt of blood transfusion, blood components or tissue	4,347 (2%)
Other/undetermined	7,675 (4%)
Total	202,921 (100%)

The CDC includes those born in Pattern II countries with the heterosexual contact cases. It does so based on the following statement:

> " 'Pattern II' is a term adopted by the World Health Organization, and refers to countries with a distinctive pattern HIV transmission. It is observed in areas of central, eastern, and southern Africa and in some Caribbean countries. In these countries, most of the reported cases occur in heterosexuals; the male to female

ratio is approximately 1 to 1; and perinatal transmission is more common than in other areas. Intravenous drug use and homosexual transmission either do not occur or occur at low levels." [6]

The remaining heterosexual contact cases are subdivided into the following categories, shown with cases reported through December 31, 1991:

Sex with IV drug user	6,366 (68%)
Sex with bisexual male	651 (7%)
Sex with person with hemophilia	104 (1%)
Sex with person born in Pattern II country	174 (2%)
Sex with transfusion recipient with HIV infection	240 (2%)
Sex with HIV-infected person, risk not specified	1,878 (20%)
Total	9,413 (100%)

The CDC does not itself report AIDS cases; that is the responsibility of state and local health departments. In the information provided with its public data set on the surveillance process, the CDC states:

"Although state and local health departments share AIDS surveillance data with CDC, the responsibility and authority for AIDS surveillance rests with the individual health departments. Like any reportable disease, the completeness of AIDS reporting reflects the aggressiveness with which these health departments solicit case reports. Health departments may depend on health-care providers to know and comply with reporting requirements. Alternatively, health departments may regularly contact and interact with health-care facilities or individual providers to stimulate disease reporting" [5].

In examining the accuracy of the CDC's classification of cases, except in perinatal cases, it is virtually impossible to know *with absolute certainty* how a person became infected with HIV. Originally, AIDS was referred to as GRIDS (gay-related immunodeficiency syndrome), because it appeared to be a disease that affected only homosexual men. Later, it became clear *by statistical analysis* that it primarily affected homosexual men and IV drug users, but that it could also be transmitted by penile-vaginal intercourse and blood transfusions and from an infected mother to her child. All these transmission methods are consistent with the fact that AIDS is a blood disease. However, even though the high-risk categories are known, there is no way of knowing for certain whether a particular person became infected in a particular manner, because the precise details of one's life cannot be known with absolute certainty by others. Furthermore, even the person himself may not be sure, if he or she has engaged in more than one type of activity that could in theory have resulted in the transmission of HIV.

Therefore, some cases of AIDS have been improperly classified. A few cases classified as homosexual contact or IV drug use might in fact be heterosexual contact, because the hierarchal system of classification might place some heterosexually acquired cases among persons with multiple risk factors for HIV exposure into other risk groups. However, there is a greater likelihood that cases classified as heterosexual contact are in fact homosexual contact or IV drug use, for two reasons:

1. The likelihood of transmission of HIV in the course of homosexual contact or IV drug use is far greater than in the course of heterosexual contact, because the efficiency of transmission is believed to be significantly higher and the probability that one's partner is infected is far higher.
2. Seldom would anyone have reason to conceal his heterosexuality. However, the likelihood of someone hiding his homosexuality or his IV drug use is significant. These are lifestyles that are condemned by a large part of our society and that often cause loss of jobs, ostracism, and criminal action. Studies have shown that cases that at first appeared to be attributable to heterosexual contact were actually linked to other risk classifications [28] [35]. The overall level of concealment that has occurred is difficult to determine, because it varies with the effectiveness of local health departments. However, it may well be a significant part of the cases categorized as heterosexual contact, particularly for males.

As mentioned earlier, pair studies have demonstrated that it is *possible* to transmit HIV by heterosexual means, both from male-to-female and from female-to-male. The evidence also is clear that the transmission efficiency is very low, particularly for female-to-male transmission, as shown most recently in a paper by Padian et al. [31]. In this paper, 72 male, non-drug-using partners of HIV+ women were studied, beginning in 1985. Of the 72 males, only a single one became infected through sexual contact. It is instructive to quote excerpts from the description of the couple's sexual practices and physical condition, to show why the man became infected:

> "Over the five years prior to the study, (the woman) had over 600 male partners, including over 2000 contacts with a bisexual man, an unidentified number of contacts with an intravenous drug user, and over 1000 contacts with a person she knew to be HIV-infected.
>
> "The couple reported an average of 15 sexual contacts a month for the last 7 years. Almost all of these contacts consisted of unprotected vaginal-penile and oral intercourse. The couple practiced anal intercourse twice. The couple never used condoms. . . . The woman would frequently have sexual intercourse with another partner while her husband first observed and then had intercourse with her immediately after the other partner.

> "This couple reported . . . over 100 episodes of both vaginal and penile bleeding. The cause of this bleeding could not be established. Medical data were available only by history, and over the last 5 years, the woman reported four cases of vaginal yeast infections, both reported one case of trichomoniasis, and the man reported one case of urethral gonorrhea. In addition, the woman reported a history of endometriosis and had a hysterectomy during the year prior to entry into the study" [31].

The report goes on to suggest that the man's HIV infection may have come from one of the other men who had sexual relations with his wife immediately prior to his sexual activity, rather than from his wife.

The report also states that six other of the 72 men reported penile bleeding during sexual intercourse, but did not become infected.

It is not at all surprising that this one man became infected, given his history of sexual practices, penile bleeding, and other STDs. What is clear from the study is that the efficiency of female-to-male transmission is extremely low, to the point of being virtually zero in the absence of some cofactor such as other STD or penile bleeding.

Only a very small percentage of male cases have been reported as heterosexual contact, in spite of the incentive that those in the high-risk groups have for concealing their lifestyles. Through December 31, 1991, the CDC reported the following distribution of total AIDS cases for males:

Homosexual/bisexual contact	118,362 (65%)
IV drug use (heterosexual)	35,048 (19%)
Homosexual/bisexual contact and IV drug use	13,135 (7%)
Hemophilia/coagulation disorder	1,671 (1%)
Heterosexual contact with a person with, or at increased risk for, HIV infection	2,882 (2%)
Born in Pattern II country	1,805 (1%)
Receipt of blood transfusion, blood components or tissue	2,679 (2%)
Other/undetermined	6,114 (3%)
Total	181,696 (100%)

Assuming that the "undetermined" category would be distributed in the same proportions as for the remaining cases if the facts were known, less than 2 percent of homosexual/bisexual men and IV drug users with AIDS would have to conceal their lifestyle to account for *all* the male AIDS cases that are alleged to be attributed to heterosexual contact.

This is not to suggest that all such cases actually are the result of concealment of a homosexual or IV drug lifestyle. Holmes et al. examined the issue of bias in reporting the reason for HIV infection in the paper "The Increasing Frequency of Heterosexually Acquired AIDS in the United States,

1983–88" [21]. They agreed that "as heterosexual transmission of HIV has become more widely acknowledged recently, it may have become easier for persons with AIDS to claim heterosexual exposure instead of homosexual contact or IVDU." However, they concluded that an examination of data on the percentage of AIDS cases involving Kaposi's sarcoma was "not consistent with the hypothesis that the increase in male AIDS cases attributed to heterosexual contact is due *primarily* to misclassification of homosexual or bisexual men with AIDS."

The conclusion seems to be that some, but not all, alleged female-to-male transmissions are actually the result of homosexual sex or IV drug use. In any event, true female-to-male transmission cases are relatively rare.

The situation for females is somewhat different. The following shows the distribution of total female AIDS cases through December 31, 1991:

IV drug use	10,705 (51%)
Hemophilia/coagulation disorder	42 (0%)
Heterosexual contact with a person with, or at increased risk for, HIV infection	6,531 (31%)
Born in Pattern II country	718 (3%)
Receipt of blood transfusion, blood components or tissue	1,668 (8%)
Other/undetermined	1,561 (7%)
Total	21,225 (100%)

Of the 6,531 cases categorized as from heterosexual contact, 4,484 (69 percent) are listed as sexual contact with an IV drug user. Unlike the situation for males, a significantly higher percentage (36 percent) of women who were actually IV drug users would have to conceal their use of IV drugs to account for all cases categorized as heterosexual contact with an IV drug user. However, as shown later, most heterosexual contact cases arise from sexual relations with the woman's primary sexual partner. In such cases, general reasoning would suggest that some portion of them would have in fact been sharing needles as well as beds with their regular sexual partner and were successful in concealing that fact.

Another factor in the number of female cases of heterosexually transmitted AIDS is the willingness of many heterosexual women to engage in anal sex. This form of sexual activity is generally believed to be a more efficient method of transmitting HIV than vaginal sex, for a variety of biological reasons, centering around the basic fact that the anus was never designed for that type of activity and therefore does not provide the natural lubricants that the vagina does. As a result, it is easier to damage and thereby open up blood vessels to HIV.

There is no way of accurately determining what proportion of sexual acts by women are anal rather than vaginal. However, according to a survey conducted by the Kinsey Institute, between 30 percent and 40 percent of women have tried anal intercourse [24].

To summarize, although it does not seem possible to accurately determine how many female AIDS cases reported as heterosexual contact are in fact from other causes than vaginal sex, some significant portion might be. At the same time, it also appears from the figures that the transmission of HIV during vaginal sex is more efficient (though still very low) from male-to-female than from female-to-male, and that a significant portion of the cases so reported did in fact arise from penile-vaginal sexual activity.

III. ANALYSIS OF THE IMPLICATIONS OF THE LOW EFFICIENCY OF TRANSMISSION OF HIV BY HETEROSEXUAL INTERCOURSE

This section examines some implications of the low efficiency of transmission of HIV by heterosexual intercourse; these include:

1. The change in risk levels for multiple sexual partners
2. The effect of the mix of sexual partners on risk levels
3. Risks of tertiary transmission
4. Changes in risk levels from using condoms
5. The distribution of the source of HIV infections between primary and other partners.

Actual risk levels vary based on a number of demographic and biologic factors. Of particular interest in this regard is the paper "Biologic Factors in the Sexual Transmission of Human Immunodeficiency Virus," by Holmberg et al. [20]. This paper discusses a number of possible cofactors, relating both to the degree of infectiousness of the infected partner and to the susceptibility to infection of the uninfected partner. The paper concludes with the following summary:

> "The probability that any single episode of genital-genital or anogenital sexual intercourse will result in transmission of HIV may be determined by multiple biologic factors of the infectious person, the virus itself, and the exposed susceptible person. Some of these factors are known or suspected (figure 1), and they may explain observed differences in the sexual transmission of HIV in different parts of the world, notably in Africa, where genital ulcerative disease is probably influencing the epidemiology of HIV. Several studies have shown that infection in partners of HIV-infected persons is not determined solely by numbers of sexual encounters; on the contrary, HIV-infected partners have usually had fewer sexual encounters with infectious mates than have noninfected partners [25] [37] [40]. Thus, sexually active persons should be cautioned that, to our knowledge, there

are no nonsusceptible persons and that any single sexual encounter may lead to HIV transmission. Research into biologic factors that modulate HIV transmission continues to be hampered by difficulties in identifying HIV transmitters and non-transmitters, infective and noninfective variants of HIV (if the latter exist in vivo), and persons relatively more or less susceptible to HIV infection. However, as the number of partner studies and the number enrolled in them increase, a progressively clearer idea of the biologic determinants of sexual transmission should emerge" [20].

Figure 1 in the article shows the following biologic factors considered possible risk factors in the sexual transmission of HIV. Question marks indicate factors whose effect in enhancing transmission are debatable, in the opinion of the authors of the paper.

Host Infectiousness:

- Late HIV infection: marked by low T-helper cell levels, p24 antigenemia, clinical symptoms
- (?) Early HIV infection: marked by increased T-suppressor cells, and (?) p24 antigenemia and (?) elevated antibody titers to cytomegalovirus (CMV)
- (?) Menstruation (female-to-male transmission)
- (?) Lack of integrity of vaginal sucosa from genital ulcer disease (female-to-male transmission).

Viral Virulence/Infectivity:

- (?) Variation in the viral genome, resulting in increased or decreased infectivity.

Host Susceptibility:

- Genital ulcerative disease from herpes simplex virus type 2 and syphilis (Western industrialized societies) and by chancroid and syphilis (Africa)
- (?) Lack of circumcision in men: intact foreskin
- (?) Trauma during sex, especially in post-menopausal women
- (?) Estrogen (birth control pill) use in African prostitutes
- (?) Variants of CD4 receptor molecule of T-lymphocytes
- (?) HLA haplotype or other cell surface antigens.

Considering these and other factors, risk levels ideally should be expressed in ranges, rather than as specific numbers. However, to do so would have immensely complicated the results and would have added little to this paper. Therefore, the results are presented as specific risk levels rather than ranges, with the above caveat.

A. The Change in Risk Levels for Multiple Sexual Partners

My earlier paper [33] discusses the risk of sexual activity for both homosexuals and heterosexuals, for both single and multiple acts of sexual

intercourse, both with a single partner and with multiple partners. It demonstrates that, whereas for homosexuals sexual activity with multiple partners significantly increases an already relatively high risk, for heterosexuals the risk remains about the same for any reasonable number of partners. Table 3 summarizes the results from Table 36 of the earlier paper.

TABLE 3

COMPARISON OF RISK LEVELS FOR MULTIPLE VERSUS SINGLE PARTNERS

	Risk Ratio: Multiple Partner Versus Single Partner				
		Heterosexual Men		Heterosexual Women	
Number of Sexual Acts	Homosexual Men	Partners Not High-Risk	Partners IV Drug Users	Partners Not High-Risk	Partners IV Drug Users
20	1.08	1.01	1.01	1.01	1.01
50	1.21	1.03	1.02	1.03	1.02
100	1.45	1.06	1.03	1.06	1.03
200	1.95	1.13	1.06	1.13	1.06
500	3.37	1.34	1.16	1.34	1.16

For monogamous relationships, the probability of HIV infection from a given number of sexual acts was determined by the formula:

$$i \times [1 - (1 - p)^n]$$

where

i = the probability that one's sexual partner is infected
p = the probability of infection from a single act of sex with an infected partner
n = the number of sexual acts during the period.

For the person with multiple partners, the probability of getting an HIV infection from a given number of sexual acts is as follows, assuming that one's partners are chosen at random from among the pool of persons in the risk group (that is, that there is not some element of monogamy involved):

$$1 - [1 - (i \times p)]^n$$

Table 3 demonstrates that, even for as many as 100 different sexual partners, there is only a 6 percent increase in risk for heterosexuals, as compared with the same amount of sexual activity with one partner. By comparison, there is a 45 percent increase for homosexuals. The additional risk for homosexuals is further increased by four other factors:

1. As shown in Table 35 of the earlier paper [33], the average risk of infection even from a single homosexual act is much greater than that from a single act of vaginal intercourse if the heterosexual's partner is not an IV drug user, and the risk is several times greater even if the heterosexual's partner is an IV drug user.
2. The number of sexual partners that some of the more promiscuous homosexual men have had is generally believed to be much greater than that for heterosexuals (except for prostitutes).
3. Because of the greater risks of promiscuity, the sexual partners of the homosexual man who is promiscuous are more likely to be infected than those of the less promiscuous homosexual.
4. Finally, the majority of infected homosexuals became HIV + through sexual activity. By contrast, the majority of infected heterosexuals became HIV + through IV drug use or blood transfusions. The result is that restricting one's sexual activity is far more important for homosexuals than for heterosexuals. This is discussed in more depth later.

Table 3 is based on four important assumptions:

1. The probability of one's partner being infected is the same regardless of whether the person is engaging in sexual relations with a single partner or with multiple partners.
2. The efficiency of transmission of the AIDS virus from an infected partner to an uninfected partner in a single act of sex is the same regardless of the number of times that the two persons have engaged in sexual relations with each other.
3. The level of infectivity is the same for all HIV + persons.
4. The level of susceptibility is the same for all sexual partners of HIV + persons.

Each of these assumptions needs further discussion and analysis. For the first assumption, one could argue that the probabilities differ for several reasons:

1. One is more apt to know the personal habits and background of one's primary partner than those of someone with whom the sexual episode is more casual. Therefore the risk of sexual activity with someone in one of the high-risk groups would be lower in the case of the primary partner.
2. On the other hand, one may be more anxious to engage in sexual relations with someone with whom there exists an emotional relationship than with someone who is a more casual sexual partner. As a result, one may be more willing to accept the risk of transmission of STD, including HIV, with one's regular partner. Therefore the risk of sexual activity with someone in a high-risk group may be increased in the case of the primary partner.
3. Finally, there is a tendency for people to believe that, because someone is a friend, he or she can "be trusted" and therefore would not knowingly pass on a disease, whereas the same could not be said of someone less well known. (The problem with

respect to AIDS, of course, is that many people who are HIV+ do not know of their condition.)

In any event, for the monogamous couple, one's sexual partner is either HIV+ or not. On the other hand, if one has many sexual partners, the probabilities discussed herein can be more readily applied. As shown later, it appears that a high percentage of those infected from heterosexual contact are people whose primary sexual partners are HIV+. A relatively small percentage are infected from sexual activity with those who are HIV+ but who are not the primary sexual partner of the person infected. And of course no heterosexually transmitted cases come from monogamous relationships with uninfected partners.

The second assumption is that the likelihood of transmission of HIV from an infected partner to an uninfected partner during a single sexual episode is the same regardless of the number of times the persons have previously engaged in sexual relations. This assumption is subject to question for several reasons:

1. There may be a cumulative effect from repeated exposure to HIV through sexual intercourse with an infected partner. This author is not aware of any studies that have demonstrated this to be the case. At the same time, not everything is known about the transmission of HIV. (One researcher even claims, wrongly in this author's opinion, that HIV does not cause AIDS [15].) So the ability of repeated exposure to gradually wear down the body's ability to fight off the virus cannot be completely discounted.
2. Because many people believe that they are at greater risk when engaging in casual sex rather than sex within a committed relationship, a couple probably will be less apt to use condoms or to take other precautions against STDs if they are regular sexual partners than if they are engaging in more casual sexual activity. One study showed that 39.2 percent of unmarried people had changed their behavior by adopting the use of condoms, but only 12.5 percent of married people had done so [50].
3. A couple may be more apt to engage in anal sex if they are regular sexual partners, because of a desire to keep their sex lives interesting by varying their sexual activities. As mentioned earlier, according to a survey conducted by the Kinsey Institute, 30 to 40 percent of women have tried anal intercourse. Because there appears to be a significantly higher efficiency of transmission from anal sex than from vaginal sex, this would appear to increase the risk for regular partners as compared with casual partners.
4. In most long-term relationships, the degree of sexual arousal tends to diminish over time. This in turn may lead to less vaginal lubrication, either because of a diminished effort by the male partner to arouse the female, or simply because the female generally is less aroused by her regular partner than she was in the earlier stages of

their relationship. Because vaginal lubrication helps prevent abrasions and thereby reduces the possibility of transmission of HIV infection, there may be some increase in the efficiency of transmission of HIV from an infected partner.

5. Finally, there is the possibility that heterosexuals who are more inclined to multiple sexual partners also will be more apt to have other, possibly untreated, STDs. Because studies have shown a correlation between transmission of HIV and history of other STDs [32], this in turn could increase both the probability that one's partner might be infected and the level of efficiency of transmission of HIV from that partner.

For young people, inexperienced in sexual matters, this could result in an apparent empirical correlation between multiple sexual partners and higher risk of transmission of HIV. Such young people may not recognize the symptoms of the various STDs and may fail to get them properly treated when they do occur. Because some such STDs have a significantly higher efficiency of transmission than HIV, persons with multiple sexual partners may be at a higher risk for such diseases. This in turn would increase the risk of transmission of HIV unless such diseases are properly treated on a timely basis.

On the other hand, those more experienced in sexual matters, who know the symptoms of STDs and get the necessary treatment, are not likely to have a greater incidence of HIV because of multiple partners. For example, consider the members of social/sexual clubs, who engage in recreational sexual activity with multiple partners. For obvious reasons such clubs do not allow any members under age 18 and usually not under 21. In addition, such persons generally have a primary sexual partner, with whom they are involved in a regular, frequently long-term relationship, and therefore tend to be older than the younger people who are merely promiscuous and do not have a primary sexual partner. Because they are potentially vulnerable to the spread of the more contagious STDs among the group, they generally are careful to watch for the symptoms of any STDs, and to take appropriate steps to correct any problems as quickly as possible, on those rare occasions when they occur.

As a result, most such groups have an excellent health record. To date, there is only one such club that has been reported as having any HIV+ members. In this instance, which occurred in 1986, two female members were reported as being HIV+ [8]. Both had engaged in repeated anal intercourse with two bisexual men whose HIV status could not be determined. Presumably they became infected in this manner, rather than from vaginal sexual activity. They did not infect any of their male sexual partners, even though their HIV status was not detected until some time after their infection occurred, during which time they continued their sexual activity with various other partners.

With respect to the third assumption, there is a belief that the level of infectivity of HIV+ persons varies considerably according to the length of time that the person has been infected. In general, in the first few weeks

after infection the level of infectivity is relatively high. Then as the AIDS antibodies build up in the body, the level of infectivity drops to a much lower level. Finally, in the later stages of the disease, the level of infectivity increases again to a relatively high level. This was discussed in the paper by Holmberg et al. [20] and in a paper by Hyman and Stanley [22] as follows:

> "Infectiousness of individuals carrying HIV varies as the course of the disease progresses. In studies of infected hemophiliacs and blood transfusion recipients, few of their spouses have seroconverted sooner than a year before the infected individuals developed AIDS or ARC symptoms (Goedert et al. [18]; Fischl et al. [16]). This time lag indicates that infectiousness is often minimal until late in the course of infection. However, some partners have been known to convert immediately (Weiss et al. [49]).
>
> "The infectivity may be related to the amount of free virus in the circulatory system of an infected individual. Studies indicate that the amount of free virus goes up in the first few weeks after infection (Francis et al. [17]; Sulahuddin et al. [41]) and then goes down as antibody response occurs, remaining at very low levels for years. There may be sporadic bursts of free virus and, hence, infectivity in these intermediate years because of other challenges to the immune system. As the immune system collapses in the year or so before AIDS develops, viral counts return to high levels (Robert Redfield, private communication; Lange et al. [27])" [22].

It is unclear how this might affect the comparisons of risk levels discussed here. On the one hand, if a person were having sex solely with those who had a relatively high level of infectivity, the added risk from multiple partners would be somewhat higher simply because the added risk increases with the increased efficiency of transmission. (See Table 6.) Conversely, those whose sexual partners were solely among those in the lower infectivity group would have an even lower additional risk from multiple partners (as well as a lower risk in general).

A more important question, however, is whether the monogamous person is more or less apt to be sexually involved with a person with a high infectivity level than is the person who has multiple sexual partners. Unfortunately, there does not appear to be any way to answer this question with any degree of precision. As mentioned earlier, a person might be more apt to know that his or her sexual partner was in the later stages of progression from infection to AIDS (and therefore more infectious) if the partner was the primary one rather than only one of many. On the other hand, a person might be more inclined to ignore AIDS-related symptoms if there was a committed relationship with his or her sexual partner.

The fourth assumption was also discussed in the paper by Holmberg et al. [20]. It is believed to be an important cofactor in the susceptibility to HIV infection and is discussed further later.

As mentioned previously, there probably is no way to accurately measure the extent of variation in risk because of the factors discussed above. However, it is instructive to examine the effect on the added risk of multiple partners of assuming some increase in efficiency of transmission of HIV as the number of sexual acts with the same partner increases. To do this, the formula for the probability of HIV infection for a given number of sexual acts may be modified to be:

$$i \times \{1 - [1 - p \times (1 + f \times n/2)]^n\}$$

where f = the percentage increase in the probability of infection for each additional act of sex with the same infected partner, and the remaining terms are as previously defined.

Table 4 shows the effect for the various risk situations of increasing the efficiency of transmission by various percentages of the basic risk factor for each major risk category. In developing the figures in Table 4, the probabilities that one's partner is infected were taken from Table 35 of the earlier paper [33] and are as follows:

Homosexual male:	467,213/2,703,000	= 17.28%
Heterosexual male		
Partner not high-risk	59,030/100,213,000	= 0.06%
Partner IV drug user	109,613/224,000	= 48.93%
Heterosexual female		
Partner not high-risk	17,322/87,355,000	= 0.02%
Partner IV drug user	389,904/793,000	= 49.17%

For women, the probability of transmission from the first act of sex with an infected partner is assumed to be one in 800, or 0.00125. For men, it has been assumed that the efficiency is one-half that for women, or 0.000625. The actual female-to-male efficiency may well be even lower, as discussed earlier.

Table 4 shows ratios of risk for single versus multiple partners for values of $f = 0.001$ and 0.005, in addition to the value of $f = 0$, which implies no additional efficiency of transmission with repeated sexual acts with the same person.

TABLE 4

RATIO OF RISK FOR MULTIPLE VERSUS SINGLE PARTNERS

Number of Sexual Acts	Percentage Increase in Probability of Infection per Sexual Act with Same Person			Percentage Increase in Probability of Infection per Sexual Act with Same Person		
	0.0%	0.1%	0.5%	0.0%	0.1%	0.5%
	Heterosexual Female Partner Not High-Risk			Heterosexual Female Partner IV Drug User		
20	1.01	1.00	0.96	1.01	1.00	0.96
50	1.03	1.01	0.92	1.02	0.99	0.91
100	1.06	1.02	0.86	1.03	0.99	0.84
200	1.13	1.04	0.80	1.06	0.98	0.75
500	1.34	1.15	0.83	1.16	0.99	0.71
	Heterosexual Male Partner Not High-Risk			Heterosexual Male Partner IV Drug User		
20	1.01	1.00	0.96	1.00	0.99	0.96
50	1.02	0.99	0.90	1.01	0.98	0.90
100	1.03	0.98	0.83	1.02	0.97	0.82
200	1.06	0.97	0.73	1.03	0.94	0.71
500	1.16	0.97	0.62	1.08	0.90	0.57

Table 4 demonstrates that for even a very small increase in the efficiency of transmission over time with the same partner (0.001 per act, or doubling the efficiency after 1000 acts), the small additional risk of multiple partners is largely or entirely eliminated. It also shows that if the increase in efficiency is assumed to be 0.005, or doubling the efficiency after 200 acts with the same partner, the risks are significantly *lower* for the person whose sexual activity involves multiple partners than for those who restrict themselves to the same amount of sexual activity with one partner (assuming the other factors discussed above to be the same).

As mentioned, there probably is no way to accurately estimate a reasonable value for the factor f, and in any event it would vary from individual to individual. However, considering the several reasons given above for significant increases in the value of f over time with the same partner, a value of 0.001 or higher does not seem unreasonable for many if not most persons, and a value in the range of 0.005 seems possible for at least a portion of heterosexuals.

Of course there also could be some increase in efficiency for repeated acts with multiple partners. Therefore the values of f used in Table 4 should really be viewed as the *difference* in increase in efficiency between the single- and multiple-partner situation. However, the reasons given above for increases in efficiency in the single-partner situation generally would not

apply to the multiple-partner situation, and so it would seem that any increases in efficiency for the multiple-partner situation would generally be very small.

The results discussed above are due entirely to the very low efficiency of transmission of HIV by heterosexual intercourse. To further illustrate this point, Table 5 shows corresponding data for homosexual men.

TABLE 5

RATIO OF RISK FOR MULTIPLE VERSUS SINGLE PARTNERS FOR HOMOSEXUAL MEN

Number of Sexual Acts	Percentage Increase in Probability of Infection per Sexual Act with the Same Person		
	0.0%	0.1%	0.5%
20	1.08	1.07	1.03
50	1.21	1.19	1.11
100	1.45	1.41	1.28
200	1.95	1.90	1.78
500	3.37	3.36	3.35

As Table 5 shows, the increases in the value of the factor f result in some decrease in risk factors; however, these decreases are small compared with the factors themselves, which are considerably greater than 1. This indicates that, for homosexuals, multiple partners increase risk levels significantly for any reasonable value of f.

The figures shown in Table 5 are based on the assumption that the efficiency of transmission of HIV by anal sex among homosexuals is 0.01, that is, that there is a 1 percent chance of transmission for a single episode of receptive anal sex with an infected partner. However, the actual efficiency of transmission for anal sex might be somewhat higher. To examine the effect of higher levels of efficiency and to better illustrate why health-care professionals with expertise in other, more readily transmitted, STDs have been unduly concerned that multiple sexual partners would contribute to the spread of heterosexually transmitted AIDS, Table 6 has been developed. This table shows the additional risk of infection for several levels of efficiency of transmission and proportion of contacts who are infected. Four levels of efficiency of transmission have been selected:

1. 0.001 per contact, approximately representative of heterosexually transmitted HIV
2. 0.01 per contact, assumed to be approximately representative of homosexually transmitted HIV

3. 0.1 per contact, roughly representative of a fairly contagious disease
4. 0.25 per contact, which might represent a highly contagious disease.

TABLE 6

VARIATION IN RATIOS OF MULTIPLE TO SINGLE PARTNER RISK LEVELS BY LEVEL OF EFFICIENCY OF TRANSMISSION AND PROPORTION OF CONTACTS INFECTED

Number of Contacts	Probability of Infection from Single Contact: 0.001				Probability of Infection from Single Contact: 0.01			
	Percentage of Contacts Infected:				Percentage of Contacts Infected:			
	0.1%	1%	10%	50%	0.1%	1%	10%	50%
20	1.01	1.01	1.01	1.00	1.10	1.10	1.09	1.05
50	1.02	1.02	1.02	1.01	1.27	1.26	1.24	1.12
100	1.05	1.05	1.05	1.02	1.58	1.57	1.50	1.24
200	1.10	1.10	1.09	1.05	2.31	2.29	2.09	1.46
500	1.27	1.27	1.24	1.12	5.02	4.91	3.96	1.85
	Probability of Infection from Single Contact: 0.1				Probability of Infection from Single Contact: 0.25			
	Percentage of Contacts Infected:				Percentage of Contacts Infected:			
	0.1%	1%	10%	50%	0.1%	1%	10%	50%
20	2.27	2.26	2.07	1.46	5.00	4.90	3.99	1.87
50	5.01	4.90	3.97	1.86	12.42	11.76	7.18	2.00
100	9.95	9.52	6.34	1.99	24.69	22.14	9.20	2.00
200	19.80	18.14	8.66	2.00	48.78	39.38	9.94	2.00
500	48.77	39.36	9.93	2.00	117.52	71.39	10.00	2.00

In addition, several levels of proportion of contacts that are infected have been selected, from 0.1 percent, which is somewhat higher than the percentage of non-IV-drug-using heterosexuals who are infected with HIV, to 50 percent, which might represent the proportion of HIV + persons in certain homosexual or IV drug groups.

To simplify the table, it is assumed that the efficiency of transmission does not vary according to the number of contacts with a particular individual, even though, as just discussed, this may not be the case.

Several points are worth noting about Table 6:

1. As already discussed, the additional risk of infection arising from multiple partners is very small if the efficiency of transmission is low and very large if the efficiency of transmission is high.

2. For a given efficiency of transmission, the additional risk decreases as the percentage of contacts already infected increases.
3. The ratio of multiple to single risk levels increases with the number of contacts and is asymptotic to the reciprocal of the percentage of contacts already infected. (In other words, if the percentage of contacts already infected is, for example, 20 percent, the ratio of multiple to single partner risk factors would be asymptotic to 5.) This result may be confirmed by general reasoning, in that in the multiple-partner situation, one ultimately is certain to become infected, provided there are any infected persons in the pool of contacts and assuming an infinite number of contacts. (However, for a low efficiency of transmission, the number of contacts required to come anywhere near the asymptote becomes extremely large—far greater than any reasonable actual level of contacts.) On the other hand, with a single partner the probability of infection is simply the reciprocal of the probability that one's partner is infected.

B. The Effect of the Mix of Sexual Partners on Risk Levels

Table 35 of the earlier paper [33] shows the variations in average risk levels for the different risk groups. For heterosexuals, there are extremely large differences in average risk levels for those involved with IV drug users, as compared with the risk levels for those who are not. Also, risk levels for whites are significantly lower than those for non-whites. Specifically, Table 7 summarizes the results from Table 35 of the earlier paper, assuming that the risk factor for heterosexual men is one-half that for women.

TABLE 7

AVERAGE RISK OF HIV INFECTION FROM SINGLE SEXUAL ACT

Race	Probability of Infection: One in:	
	Partner Not High-Risk	Partner IV Drug User
Heterosexual Women		
White	11,089,000	1,547
Black	787,566	1,654
Other	1,489,259	1,645
All	4,034,407	1,627
Heterosexual Men		
White	4,351,184	3,104
Black	1,657,486	3,316
Other	682,108	3,316
All	2,716,260	3,270

If it were possible for a person to know whether or not his or her sexual partner was an IV drug user, it would be relatively easy to select sexual partners who presented a risk of HIV infection too remote to be of rational concern. Unfortunately, this is not always the case. Furthermore, some may not be willing to reject a sexual partner because of possible IV drug use. Also, there is a substantial difference between the risk of a single sexual episode with someone and that of a regular sexual relationship. Therefore it is instructive to examine the results of a matrix showing the combined effect of (1) the degree to which IV drug users are included in the "pool" of potential sexual partners and (2) the number of sexual acts.

Table 8 shows the substantial variations in risk levels that occur because of variations in the mix of sexual partners. For females, the probability that her partner is infected was calculated to be:

$$\frac{IDM_n \times m + IM_n \times (1 - m)}{NDM_n \times m + NM_n \times (1 - m)}$$

where

m = the "mix factor." A value of $m = 0$ means that the woman is able to exclude 100 percent of IV drug users from her potential sexual partners, while a value of $m = 1$ means that her sexual partners consist exclusively of IV drug users. Thus a "mix factor" of 0.1 indicates that the person's sexual partner has been chosen at random from a pool of people consisting of 90 percent of the total number of drug-free heterosexuals, plus 10 percent of the total number of IV drug users. A "mix factor" of 0.5 indicates that one's sexual partner has been chosen completely at random (except for race) from the total adult heterosexual population.

IDM_n = the number of male IV drug users in that racial category already infected with HIV by year n.

IM_n = the number of male drug-free heterosexuals in that racial category already infected with HIV by year n.

NDM_n = the total number of male IV drug users in that racial category in year n.

NM_n = the total number of male drug-free heterosexuals in that racial category in year n.

TABLE 8

RISK OF HIV INFECTION FOR VARIOUS MIX FACTORS

Mix Factor	Probability That Partner Is HIV+	Probability of HIV Infection: One in: Number of Sexual Acts			
		1	5	25	250
Heterosexual Male, White Sexual Partner					
0	0.04%	4,351,184	871,325	175,356	18,794
0.10	0.04	3,992,860	799,571	160,915	17,247
0.25	0.05	3,428,317	686,521	138,164	14,808
0.50	0.07	2,407,616	482,125	97,029	10,399
0.75	0.13	1,272,653	254,849	51,289	5,497
0.90	0.30	528,570	105,846	21,302	2,283
0.99	2.82	56,769	11,368	2,288	245
1	51.55	3,104	622	125	13
Heterosexual Male, Black Sexual Partner					
0	0.10%	1,657,485	331,912	66,798	7,159
0.10	0.16	977,034	195,651	39,375	4,220
0.25	0.30	537,531	107,641	21,663	2,322
0.50	0.70	230,246	46,107	9,279	995
0.75	1.85	86,575	17,337	3,489	374
0.90	5.00	32,033	6,415	1,291	138
0.99	26.80	5,969	1,195	241	26
1	48.24	3,317	664	134	14
Heterosexual Female, White Sexual Partner					
0	0.01	11,089,000	2,223,351	450,249	51,620
0.10	0.02	3,861,447	774,223	156,787	17,975
0.25	0.05	1,677,043	336,248	68,093	7,807
0.50	0.13	622,614	124,835	25,280	2,898
0.75	0.37	216,600	43,428	8,795	1,008
0.90	1.08	74,170	14,871	3,012	345
0.99	9.77	8,188	1,642	332	38
1	51.73	1,547	310	63	7
Heterosexual Female, Black Sexual Partner					
0	0.10	787,566	157,907	31,978	3,666
0.10	0.35	231,164	46,348	9,386	1,076
0.25	0.83	96,652	19,379	3,924	450
0.50	2.22	36,095	7,237	1,466	168
0.75	5.94	13,480	2,703	547	63
0.90	14.20	5,636	1,130	229	26
0.99	39.65	2,018	405	82	9
1	48.37	1,654	332	67	8

For males, an analogous formula was used:

$$\frac{IDF_n \times m + IF_n \times (1 - m)}{NDF_n \times m + NF_n \times (1 - m)}$$

where

IDF_n = the number of female IV drug users in that racial category already infected by year n.

IF_n = the number of female drug-free heterosexuals in that racial category already infected with HIV by year n.

NDF_n = the total number of female IV drug users in that racial category in year n.

NF_n = the total number of female drug-free heterosexuals in that racial category in year n.

The values for the above were taken from Table 35 of the earlier paper [33], thus reflecting risk levels in 1988. Overall comparative risk levels have not changed materially since then, although there may have been changes in particular geographical locations.

For females, the risk from bisexual males has been omitted from the tables to simplify the analysis. According to the CDC, about 10 percent of female AIDS cases that are identified as heterosexually transmitted are the result of sexual contact with a bisexual male.

Four values for the number of sexual acts are shown in Table 8:

1. A single sexual act, illustrating the risk level for the "one-night stand."
2. Five sexual acts, illustrating the risk level for the person who has a few episodes of sex with someone.
3. 25 sexual acts, illustrating the risk level for the person who has a significant number of sexual episodes with someone but who does not develop a long-term relationship with that person.
4. 250 sexual acts, illustrating the risk level for the person who has a relatively long-term relationship with a sexual partner.

In determining what mix factor might be appropriate for a given situation, remember that it is not the use of IV drugs that spreads HIV, but rather the sharing of contaminated needles. Therefore the IV drug user who is at high risk of being HIV+ is most likely to be one who is unable to afford the price of clean needles and not intelligent or caring enough to clean a used one before reusing it. The majority of the population is unlikely to unknowingly have a sexual encounter with an IV drug user who shares needles.

Several points shown in Table 8 are worth discussing:

1. Of most significance is the enormous differences in risk levels. On the one hand, the white heterosexual woman who can be sure enough of her sexual partner to be sure that he is not an IV drug user (or a bisexual) has an average risk from a "one-night stand" of less than one in 11 million—clearly of no rational concern. On the other extreme, the person with a long-term sexual relationship with someone who is an IV drug user has about one chance in 8 of becoming HIV+ because of the sexual relationship.
2. The increase in the mix factor is relatively unimportant for most of the population. Such people probably are unlikely to encounter IV drug users in the course of their sexual encounters. An increase from 0.0 to 0.1 in the mix factor results in only relatively modest changes in the risk factors, still leaving them at levels that would have to be characterized as remote, particularly for whites.
3. On the other hand, the mix factor is significant for those more closely associated with the IV drug community. An increase from 0.9 to 1.0 in the mix factor results in very large percentage increases in what are already more significant risk levels. For a single sexual encounter, these increases are more than tenfold for white males. For multiple encounters, they are much higher in some cases.
4. The ability to use good judgment in choosing sexual partners becomes much more important for the steady sexual relationship than for the brief encounter. For example, the white female who makes no attempt to discriminate as to her sexual partners other than to choose a man of the same race has on the average only one chance in about 600,000 in becoming HIV+ from a single sexual episode. By contrast, the long-term relationship with the same person results in an average risk of about one in about 3,000 (albeit over a period of time).
5. Risk levels are significantly higher for those choosing black sexual partners than for those choosing white sexual partners. This conclusion is based on CDC data which continue to show disproportionately higher numbers of AIDS cases among blacks than among whites.

Table 8 illustrates the need for a better focus in AIDS education and prevention efforts directed towards heterosexuals. The person whose sexual partners are highly likely to be chosen from within the IV drug community is at significant risk and is well advised to take steps to reduce or eliminate the possibility of transmission of HIV. On the other hand, the majority of people, who are unlikely to come in contact with IV drug users in the course of their sexual encounters, are subject to risk levels that can only be described as remote. As shown later, subjecting them to constant warnings about the risks of getting AIDS from sexual encounters may be doing them harm in their general lives and happiness, and will do little or nothing to prevent the spread of AIDS.

C. Risks of Tertiary Transmission

A common warning about heterosexually transmitted HIV is that "you don't know who he (or she) has been with, and so you shouldn't take the risk." In fact, because of the low efficiency of heterosexual transmission, in most cases the risk of such "tertiary" infection is remote. Table 9 examines the actual level of risk involved. It shows the probabilities of transmission from a woman with various percentages of probability of being HIV+, to a previously uninfected man, and then to a previously uninfected woman. In developing this table, the formula for the probability of transmission for multiple acts with the same partner was used for both stages of transmission. Also, it was assumed that the efficiency of male-to-female transmission is one in 800 per sexual act with an infected partner, and one in 1,600 for female-to-male transmission per sexual act with an infected partner.

A table for transmission from a male to a female, and then to a male, would give results very similar to those in Table 9.

As with Table 8, Table 9 shows an enormous range of risk levels. The woman who is contemplating a single episode of sex with a partner who has had other sexual partners generally need not be concerned about whom her partner might have been with in the past unless he had had many sexual encounters with previous partners who were IV drug users (or known to be HIV+). For example, even if her sexual partner has had 25 episodes of sex with partners with a probability of HIV infection of 0.1 (which, as Table 8 shows, implies a mix factor in excess of 90 percent for blacks and 99 percent for whites), her risk of HIV infection would be only about one-in-half-a-million—clearly a remote risk.

For the more typical situation involving persons not themselves in high-risk groups, the woman's contemplated partner might have been having sexual encounters with partners whose mix factors were about 10 percent or less. Assuming a 10 percent mix factor for his sexual partners, her probability of becoming infected because of his previous sexual partners drops to between one-in-about-5-million and less than one-in-1-billion, depending on race and the number of his previous sexual encounters.

The figures from Table 9 can be compared with those in Table 8, which show risks for sexual partners with various mix factors, without regard to how such partners became HIV+. Such comparison indicates that, unless one's contemplated partner has been engaged in a great deal of sexual activity with persons with a greater mix factor than he himself falls in, the principal

TABLE 9

PROBABILITY OF TERTIARY HETEROSEXUAL TRANSMISSION OF HIV TO FEMALE

Number of Sexual Acts with Previous Partner	Probability of Tertiary Infection: One in: Number of Sexual Acts: 1	5	25	250
Probability That Previous Partner Was HIV+: 0.001				
1	1,280,000,000	256,640,800	51,972,163	5,958,424
5	256,320,200	51,392,360	10,407,434	1,193,175
25	51,585,040	10,342,833	2,094,520	240,129
250	5,528,816	1,108,531	224,488	25,737
Probability That Previous Partner Was HIV+: 0.01				
1	128,000,000	25,664,080	5,197,216	595,842
5	25,632,020	5,139,236	1,040,743	119,318
25	5,158,504	1,034,283	209,452	24,013
250	552,882	110,853	22,449	2,574
Probability That Previous Partner Was HIV+: 0.05				
1	25,600,000	5,132,816	1,039,443	119,168
5	5,126,404	1,027,847	208,149	23,864
25	1,031,701	206,857	41,890	4,803
250	110,576	22,171	4,490	515
Probability That Previous Partner Was HIV+: 0.1				
1	12,800,000	2,566,408	519,722	59,584
5	2,563,202	513,924	104,074	11,932
25	515,850	103,428	20,945	2,401
250	55,288	11,085	2,245	257
Probability That Previous Partner Was HIV+: 0.25				
1	5,120,000	1,026,563	207,889	23,834
5	1,025,281	205,569	41,630	4,773
25	206,340	41,371	8,378	961
250	22,115	4,434	898	103
Probability That Previous Partner Was HIV+: 0.5				
1	2,560,000	513,282	103,944	11,917
5	512,640	102,785	20,815	2,386
25	103,170	20,686	4,189	480
250	11,058	2,217	449	51
Probability That Previous Partner Was HIV+: 1.0				
1	1,280,000	256,641	51,972	5,958
5	256,320	51,392	10,407	1,193
25	51,585	10,343	2,095	240
250	5,529	1,109	224	26

risk by far is not that he became HIV+ from a previous partner, but that he is HIV+ because of some nonheterosexual activity, such as IV drugs, sex with another male, or a transfusion with HIV-infected blood.

This is not a surprising result, considering that, as discussed, according to the CDC most heterosexually transmitted AIDS cases involve infection from sexual partners who are known to be IV drug users, bisexual men, hemophiliacs, or recipients of infected blood. Only 20 percent are classified as having come from heterosexual contact with an HIV-infected person, risk not specified. Presumably some, and perhaps most, of them also became infected because of sexual contact with someone in one of the high-risk groups.

The results shown in Table 9 are contrasted with comparable figures for the homosexual situation in Table 10, based on the assumption that the efficiency of transmission is 0.01 per homosexual act with an infected partner. Because it is estimated that well over 10 percent of homosexuals are HIV+, figures have been shown only for probabilities of 10 percent or more that the previous partner is infected.

TABLE 10

PROBABILITY OF TERTIARY HOMOSEXUAL TRANSMISSION OF HIV

Number of Sexual Acts with Previous Partner	Probability of Tertiary Infection: One in: Number of Sexual Acts:			
	1	5	25	250
Probability That Previous Partner Was HIV+: 0.1				
1	100,000	20,404	4,501	1,088
5	20,404	4,163	918	222
25	4,501	918	203	49
250	1,088	222	49	12
Probability That Previous Partner Was HIV+: 0.25				
1	40,000	8,162	1,800	435
5	8,162	1,665	367	89
25	1,800	367	81	20
250	435	89	20	5
Probability That Previous Partner Was HIV+: 0.5				
1	20,000	4,081	900	218
5	4,081	833	184	44
25	900	184	41	10
250	218	44	10	2
Probability That Previous Partner Was HIV+: 1.0				
1	10,000	2,040	450	109
5	2,040	416	92	22
25	450	92	20	5
250	109	22	5	1

The figures in Table 10 are based on the assumption of a monogamous (or in this case, serially monogamous) sexual relationship; however, because HIV infection has spread through the homosexual community in major part because of promiscuous sexual activity, the actual risk levels would be somewhat greater than shown above, depending on the levels of promiscuity involved. Also, many promiscuous homosexuals have had an extremely large number of sexual partners, thereby further increasing the importance of knowing the HIV status of prior homosexual partners.

Comparison of Tables 9 and 10 clearly shows that, although one's previous sexual partners are important in analyzing the risk of HIV transmission for homosexuals, they are of little importance for heterosexuals, except for those planning long-term relationships with someone who may have in turn had another long-term relationship with someone in a high-risk group.

D. Changes in Risk Levels from the Use of Condoms

Much effort currently is being made to encourage persons to use condoms when engaging in sexual activity. Certainly if two people are going to engage in sexual activity in any event, the proper use of a condom will reduce whatever risk would otherwise exist of transmission of AIDS and other STDs, and of unwanted pregnancy. However, there also are disadvantages in AIDS education efforts about condoms:

1. A person may increase the frequency of sexual activity if he or she believes that there is little or no risk from such activity because of condom usage.
2. A person may be less selective in choosing sexual partners if he or she believes that the condom offers protection.
3. The constant publicity about condoms, and their easy availability, may encourage sexual activity that otherwise might not occur.

In addition, five other points must be recognized:

4. In spite of some efforts to "glamorize" the use of condoms, such as by attempting to show how one can be applied without detracting from the moment or claiming that it can add to the physical pleasure of sex, most people feel that condoms detract from the spontaneity and pleasure of sexual activity. Application of a condom can be intrusive if a sexual episode is to consist of a variety of oral, manual, and genital activities designed to provide maximum sexual pleasure for all involved.
5. With regard to the use of condoms for AIDS prevention (as contrasted to their use for birth control), their intrusion into the love-making process raises the question of whether or not one's partner has a fatal disease, and one that has a great deal of stigma attached to it, at a time when thoughts should be elsewhere, if the sexual activity is to be fully enjoyed.

6. Condoms are more apt to be used for disease prevention in the case of "one-night stands" or other relatively casual sexual activity, than for sexual activity with one's primary sexual partner. This is because in most cases if a person has a regular sexual relationship with someone, there is likely to be an element of trust that would not normally exist to the same degree with a more casual partner. Yet, as shown later, most heterosexually transmitted HIV infections come from one's primary partner.
7. Condoms are most likely to be used by the more "socially responsible" middle class. The people who are most at risk for heterosexually transmitted AIDS—the younger, disadvantaged groups, disproportionately black or hispanic—may be less apt to use condoms.
8. Finally, urging the use of condoms gives a mixed and confusing message to many. If it is intended to apply only to sexual activity with other than a primary partner, few cases of HIV infection will be prevented. On the other hand, if it is intended to apply to *all* sexual activity, it makes no logical sense, because it is in effect promoting the eventual extinction of the human race by reducing the birth rate to zero.

To analyze the effect of the first three points, a table was developed to analyze the offsetting benefit of reduction in the efficiency of HIV transmission and disadvantages of (1) greater frequency of sexual relations and (2) less discrimination in choosing sexual partners with condom usage. The table calculates the probability of HIV infection from sexual activity without using condoms, using the following formula for females:

$$ {}_nP_v = 1 - [1 - (i_m \times p)]^n $$

where

$ {}_nP_v $ = the probability of HIV infection from n episodes of vaginal sexual activity, if no condom is used.
$ i_m $ = the probability that one's sexual partner is HIV+.
$ p $ = the probability of transmission of HIV infection from a single sexual contact with an infected partner.
$ n $ = the number of sexual episodes of vaginal sexual activity.

The formula for calculating $ i_m $ is as follows:

$$ \frac{IM \times (1 - m) + (IDM \times m)}{NM \times (1 - m) + (NDM \times m)} $$

where

$ IM $ = the number of HIV+ male heterosexuals, excluding IV drug users, in a given racial category.

IDM = the number of HIV+ male heterosexual IV drug users in a given racial category.
NM = the total number of male heterosexuals, excluding IV drug users, in a given racial category.
NDM = the total number of male heterosexual IV drug users in a given racial category.
m = the mix factor, described earlier in the paper.

Next, the probability of HIV infection from sexual activity using a condom is calculated by using the following formula:

$$ {}_cp_v = 1 - [1 - (j_m \times p \times s)]^n $$

where

${}_cp_v$ = the probability of HIV infection from c episodes of vaginal sexual activity, if a condom is used.
j_m = the probability that one's sexual partner is HIV+.
s = the "safety factor" achieved by using a condom. For example, if the condom were effective 90 percent of the time, the safety factor would be 0.1.

The formula for calculating j_m is as follows:

$$ \frac{IM \times (1 - m_c) + (IDM \times m_c)}{NM \times (1 - m_c) + (NDM \times m_c)} $$

where

m_c = the mix factor for a person using condoms, and all other terms are as described above.

Tables 11 through 13 show the average risk levels for a single sexual contact without a condom, and the ratios of the risk level with a condom to that without a condom, for various assumptions on the percentage that (1) sexual activity and (2) the mix factor would be increased by condom usage. A ratio greater than 1 indicates that, based on the assumptions indicated, the risk with a condom is *greater* than that without a condom. A ratio less than 1 indicates that the use of a condom results in some reduction in the risk of HIV infection.

In these tables it has been assumed that the condom safety factor is 0.1 and that the female-to-male transmission efficiency is 1 in 1,600, or 50 percent of that for male-to-female. The actual failure rate of condoms would vary according to whether they were used correctly, with a spermicide, etc.

The 10 percent failure rate has been used by various authors, including Hearst and Hulley [19].

Table 11 shows the effect of condom usage if the mix factor is increased to 1.0 because of condom usage but no increase occurs in the frequency of sexual activity. This illustrates the case of someone who might otherwise be using care in choosing sexual partners without condom usage, but because he or she believes that the condom provides full protection against HIV transmission, feels that it is safe to engage in sexual relations exclusively with persons who use IV drugs. This type of situation might occur with someone who already is sexually very active and who normally is choosing sexual partners (or perhaps a single partner) from within the drug community except for the risks of HIV infection if a condom were not being used.

Table 12 shows the effect of a fivefold increase in sexual activity, combined with an increase in the mix factor such that the new mix factor is 75 percent of the maximum possible increase. (In other words, if, for example, the original factor was 0.2, the new factor would be 0.8.) This type of situation might occur with someone who decided that the use of a condom meant that he or she could substantially increase the frequency of sexual activity and need not be concerned about the type of sexual partner.

Tables 11 and 12 illustrate the situation for those whose choice of IV drug users as sexual partners would be much more likely and whose sexual activity would be substantially increased if a condom were used. These tables show that under such circumstances using good judgment in choosing sexual partners is far more important than using a condom. For example, the white female who selects her sexual partner from the IV drug community, but insists that he use a condom, is more than 700 times as likely to become infected with HIV than one who is not concerned about getting her partner to use a condom, but who chooses her partner from among those who are not involved with IV drugs. Only in the case of those whose sexual partners already are highly likely to be chosen from among those who use IV drugs does the use of a condom actually reduce the risk of HIV infection.

Table 13 illustrates the situation for those for whom the amount of sexual activity would not be increased if a condom were used, but for whom the mix factor would be increased by 50 percent of the maximum possible amount if a condom were used.

Table 13 shows that, under the assumption of no increase in sexual activity but a less careful selection of sexual partners when a condom is used, there will be some reduction in risk for males when a condom is used, but there

TABLE 11

CHANGE IN RISK IN SINGLE SEXUAL ENCOUNTER FROM USE OF CONDOM
NO INCREASE IN SEXUAL ACTIVITY, MIX FACTOR INCREASED TO 100%

Mix Factor		Probabilty of HIV Infection: One in:		
Without Condom	With Condom	Without Condom	With Condom	Ratio
Heterosexual Male, White Sexual Partner				
0.00	1.000	4,351,184	31,038	140.19
0.10	1.000	3,992,860	31,038	128.64
0.20	1.000	3,620,249	31,038	116.64
0.50	1.000	2,407,616	31,038	77.57
0.75	1.000	1,272,653	31,038	41.00
0.90	1.000	528,570	31,038	17.03
0.99	1.000	56,769	31,038	1.83
1.00	1.000	3,104	31,038	0.10
Heterosexual Male, Black Sexual Partner				
0.00	1.000	1,657,485	33,170	49.97
0.10	1.000	977,034	33,170	29.46
0.20	1.000	646,377	33,170	19.49
0.50	1.000	230,246	33,170	6.94
0.75	1.000	86,575	33,170	2.61
0.90	1.000	32,033	33,170	0.97
0.99	1.000	5,969	33,170	0.18
1.00	1.000	3,317	33,170	0.10
Heterosexual Female, White Sexual Partner				
0.00	1.000	11,089,000	15,466	716.99
0.10	1.000	3,861,447	15,466	249.67
0.20	1.000	2,128,407	15,466	137.62
0.50	1.000	622,614	15,466	40.26
0.75	1.000	216,600	15,466	14.00
0.90	1.000	74,170	15,466	4.80
0.99	1.000	8,188	15,466	0.53
1.00	1.000	1,547	15,466	0.10
Heterosexual Female, Black Sexual Partner				
0.00	1.000	787,566	16,540	47.62
0.10	1.000	231,164	16,540	13.98
0.20	1.000	123,412	16,540	7.46
0.50	1.000	36,095	16,540	2.18
0.75	1.000	13,480	16,540	0.82
0.90	1.000	5,636	16,540	0.34
0.99	1.000	2,018	16,540	0.12
1.00	1.000	1,654	16,540	0.10

TABLE 12

CHANGE IN RISK IN SINGLE SEXUAL ENCOUNTER FROM USE OF CONDOM
500% INCREASE IN SEXUAL ACTIVITY, MIX FACTOR INCREASED BY 75%

"Mix" Factor		Probability of HIV Infection: One in:		
Without Condom	With Condom	Without Condom	With Condom	Ratio
Heterosexual Male, White Sexual Partner				
0.00	0.750	4,351,184	2,121,089	2.05
0.10	0.775	3,992,860	1,920,216	2.08
0.20	0.800	3,620,249	1,717,069	2.11
0.50	0.875	2,407,616	1,093,592	2.20
0.75	0.938	1,272,653	557,331	2.28
0.90	0.975	528,570	227,989	2.32
0.99	0.998	56,769	27,574	2.06
1.00	1.000	3,104	5,173	0.60
Heterosexual Male, Black Sexual Partner				
0.00	0.750	1,657,485	144,291	11.49
0.10	0.775	977,034	127,177	7.68
0.20	0.800	646,377	110,927	5.83
0.50	0.875	230,246	66,759	3.45
0.75	0.938	86,575	34,446	2.51
0.90	0.975	32,033	16,723	1.92
0.99	0.998	5,969	5,638	1.06
1.00	1.000	3,317	5,529	0.60
Heterosexual Female, White Sexual Partner				
0.00	0.750	11,089,000	361,001	30.72
0.10	0.775	3,861,447	315,536	12.24
0.20	0.800	2,128,407	272,705	7.80
0.50	0.875	622,614	157,909	3.94
0.75	0.938	216,600	75,392	2.87
0.90	0.975	74,170	30,652	2.42
0.99	0.998	8,188	5,326	1.54
1.00	1.000	1,547	2,578	0.60
Heterosexual Female, Black Sexual Partner				
0.00	0.750	787,566	22,467	35.05
0.10	0.775	231,164	19,957	11.58
0.20	0.800	123,412	17,595	7.01
0.50	0.875	36,095	11,277	3.20
0.75	0.938	13,480	6,747	2.00
0.90	0.975	5,636	4,295	1.31
0.99	0.998	2,018	2,907	0.69
1.00	1.000	1,654	2,757	0.60

TABLE 13

CHANGE IN RISK IN SINGLE SEXUAL ENCOUNTER FROM USE OF CONDOM
NO INCREASE IN SEXUAL ACTIVITY, MIX FACTOR INCREASED BY 50%

Mix Factor		Probability of HIV Infection: One in:		
Without Condom	With Condom	Without Condom	With Condom	Ratio
Heterosexual Male, White Sexual Partner				
0.00	0.500	4,351,184	24,076,160	0.18
0.10	0.550	3,992,860	21,903,519	0.18
0.20	0.600	3,620,249	19,683,817	0.18
0.50	0.750	2,407,616	12,726,529	0.19
0.75	0.875	1,272,653	6,561,547	0.19
0.90	0.950	528,570	2,689,161	0.20
0.99	0.995	56,769	299,684	0.19
1.00	1.000	3,104	31,038	0.10
Heterosexual Male, Black Sexual Partner				
0.00	0.500	1,657,485	2,302,462	0.72
0.10	0.550	977,034	1,937,359	0.50
0.20	0.600	646,377	1,618,528	0.40
0.50	0.750	230,246	865,746	0.27
0.75	0.875	86,575	400,554	0.22
0.90	0.950	32,033	170,447	0.19
0.99	0.995	5,969	46,376	0.13
1.00	1.000	3,317	33,170	0.10
Heterosexual Female, White Sexual Partner				
0.00	0.500	11,089,000	6,226,144	1.78
0.10	0.550	3,861,447	5,149,215	0.75
0.20	0.600	2,128,407	4,234,699	0.50
0.50	0.750	622,614	2,166,001	0.29
0.75	0.875	216,600	947,453	0.23
0.90	0.950	74,170	360,662	0.21
0.99	0.995	8,188	48,517	0.17
1.00	1.000	1,547	15,466	0.10
Heterosexual Female, Black Sexual Partner				
0.00	0.500	787,566	360,955	2.18
0.10	0.550	231,164	300,597	0.77
0.20	0.600	123,412	249,553	0.49
0.50	0.750	36,095	134,800	0.27
0.75	0.875	13,480	67,662	0.20
0.90	0.950	5,636	35,452	0.16
0.99	0.995	2,018	18,349	0.11
1.00	1.000	1,654	16,540	0.10

still will be a significant increase in risk for those females who normally would not be sexually involved with IV drug users if a condom were not used.

To summarize, the choice of sexual partner is far more important than the use of a condom in preventing the spread of heterosexually transmitted HIV infection. If one's partner is in all likelihood not from a high-risk group, the risk of HIV infection is so remote that, in terms of AIDS prevention, the protection afforded by the use of a condom is not worth the intrusion into the love-making process (although it may of course be of value for some in reducing the risk of pregnancy or the transmission of other STDs). On the other hand, if one's partner is from a high-risk group, the risk *with* the use of a condom may still be too high to be acceptable in most circumstances.

E. Distribution of Source of HIV Infections between Primary and Other Partners

There has been a great deal of talk about the need to practice monogamy to help stop the spread of HIV infections among heterosexuals. However, this advice ignores three important facts:

1. Most heterosexuals who have contracted AIDS did so from causes other than sexual activity. According to the CDC, 61,226 adult heterosexuals had been reported with AIDS through December 31, 1991. Of these, 45,753 (75 percent) were IV drug users. Another 6,060 (10 percent) were the victims of tainted blood given to them in blood transfusions, including hemophilia cases. Only 9,413 (15 percent) were from sexual activity with an HIV + person. (In addition, 2,523 persons were reported as having been born in "Pattern II" countries and are listed under "heterosexual contact" because of the pattern of AIDS cases in those countries.)
2. As previously demonstrated, because of the low efficiency of heterosexual transmission, the number of sexual partners makes little difference in the risk of HIV infection.
3. The proportion of heterosexually transmitted infections that are the result of sexual activity with one's primary partner is much higher than would be the case if the disease could be transmitted more efficiently.

The third point can be demonstrated in the following analysis. Let us assume that there are three types of heterosexuals: "monogamous," "semi-monogamous," and "multiple partners." "Monogamous" persons are those who have a sexual relationship with only one partner. "Semi-monogamous" persons are those who have a primary sexual partner, but who also have

some sexual activity with others. Those who are identified as having "multiple partners" have sexual activity with a number of people, no one of whom can be called a primary partner.

The number of monogamous people to become infected with HIV in a given period of time can be expressed by the following formula:

$$V_m = N_m \times i_m \times [1 - (1 - p)^n]$$

where

V_m = the number of monogamous people to become infected during the period.
N_m = the total number of monogamous people in the population.
i_m = the probability for monogamous people that one's sexual partner is infected with HIV.
p = the probability of becoming infected from a single act of sex with an infected partner.
n = the number of sexual acts during the period.

The number of people with multiple partners to become infected with HIV in a given period of time can be expressed by the following formula:

$$V_p = N_p \times \{1 - [1 - (i_p \times p)]^n\}$$

where

V_p = the number of people with multiple partners to become infected with HIV during the period.
N_p = the total number of people with multiple partners in the population.
i_p = the probability for people with multiple partners that one's sexual partner is infected with HIV.

The remaining symbols are as previously defined.

The number of semi-monogamous people to become infected with HIV in a given time can be expressed by the following formula:

$$V_s = N_s \times \{1 - [1 - i_s \times (1 - (1 - p)^{nm})] \times [1 - (i_s \times p)]^{np}\}$$

where

V_s = the number of semi-monogamous people to become infected with HIV during the period.
N_s = the total number of semi-monogamous people in the population.
i_s = the probability for semi-monogamous people that one's sexual partner is infected with HIV.

nm = the number of sexual acts engaged in with one's primary sexual partner during the period.

np = the number of sexual acts engaged in with people other than one's primary sexual partner during the period.

Finally, the proportion of total HIV infections caused by sexual relations with one's primary partner is as follows:

$$\frac{N_s \times \{1 - [1 - i_s \times (1 - (1 - p)^{nm})]\} + V_m}{V_m + V_s + V_p}$$

To examine the effect of the efficiency of the transmission of HIV on the proportion of heterosexual infections coming from primary partners, certain assumptions are necessary. For this analysis, we assume the following:

1. The total number of sexual acts (n) for each person in the period is 200.
2. The probabilities that one's sexual partner is HIV+ (i_m, i_s, and i_p) are all assumed to be 0.1 percent.
3. The distribution of people among the three categories is: monogamous, 50 percent; semi-monogamous, 45 percent; and multiple partners, 5 percent.
4. For those in the semi-monogamous category, the proportion of sexual acts with persons other than their primary partner was 10 percent.

The number of people in the total population does not actually affect the distribution of HIV infections among the three groups, although it does of course affect the number of infections.

Table 14 shows the effect of various levels of efficiency of transmission on the proportion of infections arising from sexual activity with one's primary partner, based on the above formulas and assumptions.

TABLE 14

PERCENTAGE OF INFECTIONS FROM PRIMARY SEXUAL PARTNER, MIDDLE ASSUMPTIONS

Probability of Transmission per Act	Percentage of Total Infections			Percentage of Infections from Primary Partners
	Monogamous	Semi-monogamous	Multiple Partners	
0.5	4.9%	48.4%	46.7%	9.3%
0.2	10.6	47.7	41.7	20.2
0.05	26.4	47.4	26.2	50.1
0.02	37.5	47.2	15.3	71.0
0.005	46.6	46.0	7.4	86.0
0.002	48.6	45.5	5.9	88.8
0.00125	49.2	45.3	5.6	89.5
0.000625	49.6	45.2	5.3	90.0
0.0001	49.9	45.0	5.0	90.4

Table 14 shows that for a disease that is easily transmitted by sexual activity, a high proportion of transmissions occurs from sexual activity with someone other than the primary partner. However, as the efficiency decreases, the proportion of transmissions that occur from sexual activity with the primary partner increases. For the efficiencies typical of heterosexual transmission of HIV, 90 percent of the transmissions would be from the primary sexual partner.

The figures in Table 14 are somewhat dependent on the assumptions. Of particular importance is the assumed distribution of people among the three categories. There is no way of knowing precisely what portion of heterosexuals are monogamous, what portion are semi-monogamous, and what portion should be considered to have multiple partners without any one primary partner. Even if the distribution were known for the population as a whole, it could well differ for those persons who are more likely to have sexual contact with HIV+ partners.

However, two references are somewhat helpful. In the article by researchers at the Kinsey Institute for Research in Sex, Gender, and Reproduction, in the November 1988 issue of *American Psychologist* [38], the following estimate is made of the degree of extramarital sexual relations:

> "Based on six data sets, we estimate that 37% (range = 26–50%) of husbands have had at least one additional sexual partner during marriage. In a study of men over 50 years old, 23% of the respondents said that they had had extramarital sexual interaction since the age of 50 (Brecher, 1984). The estimate for wives' extramarital sexual relations, based on nine studies, is 29% (range = 20–54%)."

Another study, done by the Center for Health Affairs in Chevy Chase, Maryland, showed the following percentages of respondents admitting to four or more heterosexual partners [50]:

Age 16–24	10.7%
Age 25–34	4.2%
Age 35+	2.4%

These studies suggest that the assumption of 50 percent monogamous, 45 percent semi-monogamous (with 10 percent of their sex with other than primary partners), and 5 percent multiple partners is a reasonable depiction of the distribution of sexual habits of heterosexuals and, in fact, may overstate the amount of sex with other than primary partners. However, to show the effect of varying these assumptions, two other tables are presented. Table 15 shows the results assuming a higher proportion of sex with other than

regular partners: specifically, for the assumptions of 50 percent monogamous, 40 percent semi-monogamous with 20 percent of their sexual activity with other than the primary partner, and 10 percent multiple partners. The other assumptions are the same as for Table 14.

TABLE 15

PERCENTAGE OF INFECTIONS FROM PRIMARY PARTNER, HIGH ASSUMPTIONS

Probability of Transmission per Act	Percentage of Total Infections			Percentage of Infections from Primary Partners
	Monogamous	Semi-monogamous	Multiple Partners	
0.5	2.7%	45.4%	51.9%	4.9%
0.2	6.2	44.8	49.0	11.2
0.05	18.6	44.5	36.9	33.4
0.02	30.8	44.1	25.0	54.9
0.005	44.1	41.9	13.9	74.9
0.002	47.6	40.9	11.5	79.2
0.00125	48.5	40.6	11.0	80.3
0.000625	49.2	40.3	10.5	81.1
0.0001	49.9	40.0	10.1	81.9

Table 15 shows that for the high assumptions, 80 percent of heterosexually transmitted HIV infections would come from the primary sexual partner.

Table 16 shows the results for low assumptions, namely, 60 percent monogamous, 36 percent semi-monogamous (with 5 percent of their sexual activity with other than their primary partner), and 4 percent multiple partners. Other assumptions are the same as above. This table could be considered to be an estimate of the effect of adjusting Table 14 for the effect of the greater use of condoms by those engaging in sexual activity with other than their primary partner.

Table 16 shows that under the low assumptions nearly 95 percent of heterosexually transmitted HIV infections come from one's primary sexual partner.

The conclusion to be drawn from these tables is that little is to be gained by emphasizing heterosexual monogamy as a means of reducing the spread of HIV. Less than 5 percent of all AIDS cases have come from heterosexual transmission, and probably 90 percent of these are transmitted from the primary sexual partner. Thus only about one-half of 1 percent of all AIDS cases could be prevented if strict heterosexual monogamy were practiced (and if, as a result, more people did not instead become infected from their primary partner). Realistically, only a small fraction of this number actually could be achieved.

TABLE 16

PERCENTAGE OF INFECTIONS FROM PRIMARY PARTNER, LOW ASSUMPTIONS

Probability of Transmission per Act	Percentage of Total Infections			Percentage of Infection from Primary Partners
	Monogamous	Semi-monogamous	Multiple Partners	
0.5	9.1%	32.8%	58.0%	14.6%
0.2	18.5	33.2	48.3	29.6
0.05	39.0	35.1	25.9	62.4
0.02	50.2	36.2	13.6	80.3
0.005	57.6	36.3	6.1	91.2
0.002	59.1	36.1	4.8	93.1
0.00125	59.4	36.1	4.5	93.5
0.000625	59.7	36.0	4.2	93.9
0.0001	60.0	36.0	4.0	94.1

The contrast between this conclusion and that for homosexuals is striking. Table 17 shows the same analysis based on the following assumptions:

- Distribution of population: 45 percent monogamous, 40 percent semi-monogamous (with 20 percent of sexual activity with other than primary partner), and 15 percent with multiple partners.
- Probability that partner is infected: 20 percent.

Other assumptions are the same as for heterosexuals.

TABLE 17

PERCENTAGE OF INFECTIONS FROM PRIMARY PARTNER, HOMOSEXUAL ASSUMPTIONS

Probability of Transmission per Act	Percentage of Total Infections			Percentage of Infections from Primary Partners
	Monogamous	Semi-monogamous	Multiple Partners	
0.5	14.2%	62.2%	23.6%	26.8%
0.2	15.6	58.4	26.0	29.4
0.05	22.2	45.8	32.0	41.9
0.02	29.9	42.2	28.0	55.9
0.005	40.0	40.8	19.1	71.1
0.002	42.9	40.4	16.7	74.6
0.00125	43.7	40.2	16.1	75.5
0.000625	44.3	40.1	15.5	76.3
0.0001	44.9	40.0	15.1	76.9

Although the exact assumptions in Table 17 of the percentage of sexual activity with other than primary partners may be open to question, there is no doubt that a much higher proportion of homosexuals than heterosexuals

is HIV+. There also seems to be little question that the virus is more easily transmitted by anal sex than by vaginal sex. Therefore it seems reasonable to assume, based on Table 17, that only somewhere between 30 percent and 70 percent of homosexual AIDS cases are transmitted by primary partners.

Furthermore, the actual figure may well be much less. Tables 14–17 are based on the assumption that the probability that one's sexual partner is HIV+ is the same for all three groups. This assumption probably is reasonable for heterosexuals, because such a high proportion of HIV infections comes from other than sexual activity and because the efficiency of transmission is so low. However, for homosexuals, the more promiscuous are more likely to be infected. If the probability of one's partner being infected were to be increased for those with multiple partners, the proportion of HIV infections coming from the primary partner would take a significant drop from the figures shown in Table 17.

Thus monogamy among homosexuals can play a major part in reducing the spread of HIV within a group that accounts for a significant percentage of total AIDS cases. This has been long recognized by those responsible for AIDS education among homosexuals. However, as demonstrated above, monogamy among heterosexuals makes little difference in coping with the AIDS epidemic, and as shown later, there are important disadvantages in overstating the risks for the population as a whole.

IV. PUBLIC PERCEPTIONS ABOUT THE RISKS OF AIDS FOR HETEROSEXUALS AND THEIR EFFECT ON LIFESTYLES AND PUBLIC POLICY

Public perceptions of the risks of AIDS to heterosexuals are understandably based on information provided by various sources, including the press, radio and television, and direct mailing from the government and other sources. In addition, word of mouth plays a role, as does peer pressure. All these shape public attitudes and thus influence public policy.

A. The Misinforming of the Public

We live in an age of the "30-second sound bite." A significant proportion of the public gets its knowledge about matters such as AIDS from the evening news, newspaper headlines, and other easy-to-absorb sources such as talk shows and advice columnists. Relatively few people acquire much knowledge from more reasoned sources such as scientific studies or in-depth analyses in serious books or articles in scientific publications.

The AIDS epidemic has provided the popular media with ample material. The public has been warned about the dangers of contracting HIV by sexual

intercourse. In addition, there have been stories of people who have supposedly contracted HIV from what normally would be considered to be casual contact. A number of groups have had a self interest in making the epidemic appear worse than it really is. Only rarely is the low risk level for heterosexuals mentioned. As a result, the public has been badly misinformed.

The misleading of the public has appeared in many forms, but in general has fallen into several categories:

- Gross exaggerations of the extent to which the epidemic would spread among heterosexuals, for example, the statement heard by millions of television viewers in February 1987 that "Research studies now project that one in five—listen to me, hard to believe—one in five heterosexuals could be dead from AIDS at the end of the next three years. That's by 1990" [51].
- Failure to recognize the low efficiency of transmission of HIV by assuming that sexual activity with an infected partner will cause the virus to transmit 100 percent or nearly 100 percent of the time, for example, the letter published by a nationally syndicated columnist from a woman who said, "Last night I had sex with 4,096 people. . . . I had sex with a man (who) admitted to having sex with eight . . . female partners over the last year. . . . I took those eight women and assumed that they also had slept with eight men, and each of those eight men had had sex with eight women, etc. By using simple arithmetic progression, after only three series I realized that I had been exposed somewhere along the line to 4,096 persons, plus one. How can I assume that there was no one in that family tree who was not an AIDS carrier . . . ?" The columnist had no quarrel with the analysis and replied, "You have focused on the aspect of AIDS that makes it such a terrifying disease" [26].
- Overemphasis by the media on isolated cases because of their human interest and dramatic appeal, even though they represent situations in which the risk is so remote, and many times so unproven, as to be unworthy of serious concern. The unusual makes the evening news, particularly if sex is involved. Thus the thousands of homosexual men and IV drug users who are HIV+ no longer are newsworthy; however, the person who claims, rightly or wrongly, to have contracted HIV from some act generally thought to be incapable of transmission of HIV will be given prime air time, for example, Kimberly Bergalis, who claimed to have contracted AIDS during dental treatment.

  For most news stories of unusual incidents, the public generally understands that it is something not likely to happen very often, if ever again, and is not concerned. However, the public has so little understanding of AIDS risk levels that each freak occurrence is interpreted by many as a new method of transmission and a new and significant risk to be avoided.
- Misuse of statistics, for example, the headline stating "Illinois AIDS Cases Doubled Since '89" [23]. The implication is that the *rate* of AIDS cases has doubled. In fact, the story merely states that the number of cases reported during the most recent two

years was approximately the same as the number reported previous to the most recent two years, so that the *cumulative* number of cases was double what it was two years earlier. (By the headline's logic, deaths from *any* cause could be said to be on the increase!)

- Mistakes of fact, even in publications generally relied on as being accurate, for example, the table heading in the 1991 edition of *The World Almanac and Book of Facts* listing "U.S. Metropolitan Areas with AIDS Rates of 25% or More, 1989–1990, and Cumulative Totals" [46]. In fact, the table lists cities in which the AIDS rates were more than 25 per 100,000, not 25 per 100.

The cumulative effect of these and many other similar cases of misleading information is serious public misperceptions of the disease. The extent of these misperceptions was evident in the results of a survey conducted in August 1987 by the National Center for Health Statistics [14]. Respondents were asked, "How likely do you think it is that a person will get the AIDS virus from the following?" Answer choices were "very likely," "somewhat likely," "somewhat unlikely," "very unlikely," "definitely not possible," and "don't know." The replies clearly showed the extent to which the public misunderstands the risk of contracting HIV:

- 69 percent believed that it was "very likely" or "somewhat likely" that one would get the AIDS virus from receiving a blood transfusion. (Even though there have been a number of unfortunate cases of HIV infection from blood transfusions before screening procedures were improved, the correct answer always was "very unlikely.")
- 25 percent believed it "very likely" or "somewhat likely" from *donating* blood. Only 18 percent correctly believed it to be definitely not possible.
- 21 percent believed it "very likely" or "somewhat likely" from working near someone with AIDS. Only 18 percent correctly believed it to be definitely not possible.
- 35 percent believed it "very likely" or "somewhat likely" from eating in a restaurant where the cook has AIDS. Only 11 percent correctly believed it to be definitely not possible.
- 47 percent believed it "very likely" or "somewhat likely" from sharing plates, forks, or glasses with someone who has AIDS. Only 8 percent correctly believed it to be definitely not possible.
- 31 percent believed it "very likely" or "somewhat likely" from using public toilets. Only 13 percent correctly believed it to be definitely not possible.
- 41 percent believed it to be "very likely" or "somewhat likely" from being coughed on or sneezed on by someone who has AIDS. Only 9 percent correctly believed it to be definitely not possible.
- 38 percent believed it to be "very likely" or "somewhat likely" that a person could get AIDS from mosquitoes or other insects.

Finally, 92 percent said that it was "very likely" and another 5 percent said that it was "somewhat likely" that a person would get the AIDS virus from having sex with someone who has AIDS. Less than 3 percent understood that the low efficiency of transmission made it unlikely.

This survey shows that the public has been so well "educated" about AIDS that not only are nearly all people unaware of how difficult it is to transmit HIV by penile-vaginal sexual activity, but also significant proportions of the population believe that HIV can be transmitted by various types of casual contact, even though there are no known cases of the types of transmission referred to in the survey.

The cases of unfair and unnecessary discrimination against HIV+ persons that have taken place because of these exaggerated fears number in the thousands. In 1990, the American Civil Liberties Union (ACLU) published a report titled "Epidemic of Fear" [1]. To produce the report, the ACLU sent questionnaires to more than 600 legal and advocacy organizations in the U.S. The 260 respondents reported receiving or referring approximately 13,000 complaints of HIV-related discrimination from 1983 to 1988.

Further discussion of AIDS discrimination is beyond the scope of this paper. However, these fears have had a significant effect on the lives and attitudes of those heterosexuals who are not infected with HIV but are fearful of what might happen.

B. AIDS Paranoia and Public Policy

One trend in our society today is to try to make life risk-free. To be sure, it is a commendable goal, and few people would argue against reasonable health and safety standards. However, sometimes we lose sight of the fact that risk is present at every stage in our lives regardless of how hard we try to eliminate it, that the general risk of human mortality increases every year after we reach adulthood, and that eventually all of us will succumb. Thus our objective should be not to eliminate all risk, but to balance risk with reward. A necessary part of this process is to understand the risks of our actions, so that we can make our own judgments on whether the reward justifies the risk.

For the AIDS epidemic, the paranoia that has been created in the mind of the public has led to the consideration of legislation for the purpose of preventing extremely small numbers of HIV infections, without regard to the side effects. Three examples stand out:

1. The Illinois Marriage and Dissolution of Marriage Act was amended effective January 1, 1988 to require HIV tests for all marriage applicants. The results for the first six months of 1988 were reported in the *Journal of the American Medical Association* in June 1989 [42]. Of 70,846 persons tested, only 8 tested positive for HIV, for a seropositive rate of 0.011 percent.

   The article estimated that the tests cost a total of about $2.5 million, or more than $300,000 for each person who tested positive. There is no evidence that any lives were saved.

   Because of the testing requirement, many Illinois residents crossed the border to other states to get married. During the first six months of 1988 there was a 22.5 percent decline in the number of marriage licenses issued, as compared with the same six-month period in 1987.

   The law was subsequently repealed.

2. Some states have enacted legislation making it a felony for a person who knows that he or she is HIV+ to engage in sexual intercourse. Although the impact of such legislation cannot be measured in the manner that the Illinois statute could be, the probable effects will be as follows:
   - Only rarely will anyone other than a prostitute be prosecuted.
   - Because female-to-male transmission is so rare and because most prostitutes require their customers to use a condom, few if any cases of HIV transmission will be prevented.
   - Relatively few prostitutes will leave the profession (most are in the business because they need the money and cannot support themselves elsewhere), but some will decide not to get tested (and therefore will lose the opportunity for treatment) to avoid the felony statute.
   - A few dying people will spend the rest of their lives in prison instead of getting needed treatment for their illness.

3. A Florida dentist who was HIV+ was believed to have infected five patients in his dental practice [9] [11] [12]. Because there were no other known cases of such transmission throughout the entire country, it is virtually inconceivable that all known cases would have happened in one dentist's office if standard procedures had been used. Therefore, the cases presumably occurred either because of repeated extreme negligence or because of some deliberate action. Either way, they represent an aberration rather than a pattern to be expected elsewhere.

   Nevertheless, there has been a public outcry to require that all health-care workers be tested for HIV, with the results to be made known to patients. As of this writing, the final result is not known, but if such legislation were enacted, the results are predictable:
   - All health-care workers who test positive will lose their jobs and will be unable to work in their chosen field for the rest of their lives, at considerable expense to them and to a society that must then support them. As of June 30, 1991, the CDC had received reports of 7,782 health-care workers with AIDS, including

728 physicians, 46 surgeons, 190 dental workers, 1,441 nurses, 1,179 health aides, 120 paramedics, 989 technicians, and 337 therapists [2]. Presumably many more would be reported if there were mandatory testing (unless they resigned their jobs rather than be tested).

- Because it is always possible to become HIV+ immediately following testing, there will continue to be a remote risk of transmission of HIV from a health-care worker to a patient. (However, the risk will continue to be far smaller than the many other risks that a patient subjects himself to when undergoing surgery.)
- Many millions of dollars will be spent on testing—money which would be far better spent elsewhere—with little likelihood of preventing transmission of HIV infection.

The CDC has estimated the risk of HIV transmission during exposure-prone procedures at one-in-41,000 to one-in-416,000 from an infected surgeon to a patient, and one-in-236,000 to one-in-2,600,000 from an infected dentist to a patient [2]. In opposing mandatory testing of health-care workers, health officials have characterized these risks as "remote." This author agrees with that characterization; however, it is worth comparing it with the following:

- An HIV+ prostitute requiring the use of a condom would run the risk of infecting a customer of one-in-16,000 based on an assumed female-to-male transmission efficiency of one-in-1,600 and a risk reduction factor from the condom of 0.1. In fact, because the female-to-male transmission efficiency probably is less than one-in-1,600 and because the prostitute probably would be more likely than most to be sure the condom was properly used, the risk would probably be much less, perhaps roughly the same as from a surgeon to a patient. Yet, as mentioned earlier, in some states the prostitute would be guilty of a felony if she had known that she was HIV+ because of the supposed risk to which she would have subjected her customer.
- For most people, the risk of casual sex is on the order of magnitude of one-in-a-million, roughly one order of magnitude safer than that estimated for an invasive surgical procedure if the surgeon is HIV+. Yet health officials strongly discourage such sexual activities, because of the risks of HIV transmission.

C. The Risks of Life

Previously in this paper we examined the various risk levels of contracting HIV under various conditions. We have seen that, although there are serious risks for certain heterosexuals who have continuing relationships with those in high-risk groups, the risk of an act of sex for the typical middle-class heterosexual is in the order of magnitude of "one-in-a-million" and in many cases far less. By comparison, the average risk of death from all causes for

a 25-year-old (both sexes and all races combined) is 1.18 per 1000 per year [44]. This means that the average 25-year-old has a "one-in-a-million" risk of death from all causes every *7 hours*. Yet people at that age generally are not concerned about the risk of death in the near future, in the absence of a specific situation that is perceived to involve a higher risk.

Another instructive comparison can be made with automobile fatality rates. In 1988, there were 2.4 deaths from automobile accidents per 100 million vehicle miles [45]. Assuming an average of 2 people per vehicle, this means that the risk of being killed in an automobile accident is "one-in-a-million" for every 83 miles traveled—less than two hours time at normal highway speeds. (Considering the higher automobile fatality rates for younger drivers, the number of miles presumably is significantly lower for the 25-year-old.)

A 1991 television special also referred to "one-in-a-million" risks [29]. It stated that one increased his risk of dying by one-in-a-million by:

- Traveling six miles in a canoe
- Traveling 10 miles on a bicycle
- Spending one hour in a coal mine
- Smoking 1.4 cigarettes.

This author has made no attempt to verify the accuracy of these figures; however, they are further demonstration that most of us take "one-in-a-million" risks routinely in our lives, without undue fear of the consequences, simply because we believe that the risk is too insignificant to worry about.

D. The Risk of AIDS Compared with Other Risks for Young People

Currently a major effort is being undertaken to provide AIDS education for young people. As early as the fifth and sixth grades, children are being taught about AIDS, HIV, and the risks of sex. There is a great debate about whether the use of condoms should be taught in the school system, because many young people will not practice abstinence regardless of what is urged by their elders.

Certainly young people should be discouraged from irresponsible sexual activity and taught that it can transmit STDs and result in unwanted pregnancy. However, is the risk of AIDS worth so much attention, possibly at the expense of other dangers? To answer this, let us first look at the CDC data on AIDS deaths for people under 30 during 1990. In that year, 10 deaths from heterosexually transmitted AIDS were reported for age group 13–19, and 170 deaths for age group 20–29. There is no way of knowing

for certain the age of these people at the time they became HIV+. However, for this analysis let us assume that the total of these two figures represents the number of 15- to 19-year-olds who became HIV+ from heterosexual transmission and will die of AIDS. (This number may overstate the correct number because a broader age range is being used, but understate it because not all HIV infections that ultimately will cause death have yet done so. The assumption is that the errors roughly balance.) In this manner, we can calculate an approximate mortality rate from heterosexually transmitted HIV infection per 100,000 population for that age group.

The *1990 Statistical Abstract of the United States* shows the following population figures for 1988 for the 15–19 age group (with other races included in the totals by sex but not by race):

Male	9,322,000
Female	8,926,000
White	14,765,000
Black	2,797,000

Assuming the male/female split of blacks and whites to be the same, the above figures can then be combined with the 180 AIDS deaths to calculate the following mortality rates from HIV infection for ages 15–19. (Note: 43 hispanic deaths are included with black totals because the CDC does not split hispanic AIDS cases by race. This results in some overstatement of the number of black deaths and understatement of the number of white deaths.)

Category	Population	Number of AIDS Deaths	Rate per 100,000
White male	7,542,000	3	0.04
White female	7,223,000	33	0.5
Black male	1,429,000	30	2.1
Black female	1,368,000	114	8.3

The corresponding figures for deaths from heterosexually transmitted AIDS excluding those transmitted from sexual activity with IV drug users are as follows:

Category	Population	Number of AIDS Deaths	Rate per 100,000
White male	7,542,000	1	0.01
White female	7,223,000	12	0.2
Black male	1,429,000	12	0.8
Black female	1,368,000	27	2.0

Table 18 compares the above rates with mortality from other causes of death for age group 15–19.

TABLE 18

SELECTED DEATH RATES BY CAUSE PER 100,000 POPULATION AGE GROUP 15–19 [47]

Cause of Death	Race and Sex			
	White Male	White Female	Black Male	Black Female
Heterosexually transmitted HIV	0.04	0.5	2.1	8.3
Heterosexually transmitted HIV (excluding IV drug)	0.01	0.2	0.8	2.0
Cancer	4.9	3.5	5.8	4.6
Cardiovascular	2.8	1.8	5.5	4.0
Motor vehicle accidents	55.9	25.1	27.2	8.2
Other accidents	15.1	2.8	18.3	3.5
Suicide	17.6	4.4	8.9	2.7
Homicide and legal intervention	7.3	3.0	60.0	12.0
Total (including all other)	116.3	48.7	144.2	49.0

Several points are worth noting about Table 18 and the data underlying it.

1. For heterosexually transmitted HIV there is a vast difference between the mortality levels by race and by sex. Whereas the risk of death is virtually nonexistent for white males and of relatively little significance for white females, it is more significant for blacks, particularly black females.
2. Except for black females, the mortality rate for AIDS is well below that for such causes as accident, suicide, and homicide. Furthermore, it is below that for cancer and heart disease—causes of death not normally associated with people in the 15–19-year-old age range.
3. Exclusion of deaths from AIDS arising from sexual contact with IV drug users reduces the total number of deaths from 180 to 52, a reduction of 71 percent. For black females, who are at the greatest risk, there is an 84 percent reduction; thus avoidance of sexual activity with IV drug users would result in a mortality rate for AIDS well below that for other major causes of death. (The author believes that the reduction actually is greater, because some people with AIDS may conceal their contacts with IV drug users.)

The principal causes of AIDS in the 13–24 age group are the same as those for other age groups, namely, homosexual contact and IV drug use. Through December 31, 1991, 55 percent of the 8,160 total cases for this age group were from homosexual/bisexual contact, 17 percent were from intravenous drug use, and 9 percent were from a combination of the two.

Only 9 percent were from heterosexual contact (11 percent if persons born in Pattern II countries are included).

Concern has been expressed that this age group is particularly vulnerable to the increasing spread of AIDS. However, the data do not bear this out. From 1990 to 1991 the total number of AIDS cases reported increased from 43,352 to 45,506, an increase of 5 percent. However, the number of reported cases from ages 13–24 *decreased* from 1,796 to 1,645, a decrease of 8 percent. For heterosexually transmitted AIDS, the percentage increase for the total population was 21 percent, as compared with a *decrease* of 7 percent for age group 13–24. Thus the trend of AIDS cases for this age group actually is significantly more favorable than for the population as a whole.

E. The Risks of the Fear of AIDS

In recent years, a great effort has been made to educate the population on the danger of contracting AIDS and what to do to reduce or avoid the risks. These efforts clearly have been warranted for male homosexuals and IV drug users, for whom the risks have been high. As shown by the data in this paper, they also are warranted for those heterosexuals whose regular sexual partners are likely to be from the IV drug community.

We already have seen that the *fear* of AIDS has done great harm to the personal rights of those known or even suspected of having the disease, or being part of a high-risk group. Considering that the risk of heterosexually transmitted AIDS is so small, is it also possible that the fear of AIDS can do more harm than the disease itself to the average middle-class heterosexual not involved with IV drug users?

To answer this question, we must recognize that there is no such thing as an "average" heterosexual. Some have believed from the start that the disease need not be of concern to them, at least to the point of changing their lifestyle. Considering that the rate of illegitimate births among teenagers has increased significantly in recent years [43], a relatively large proportion of those in their teens and early 20s appear to be in this group.

There are others who may be more careful when choosing sexual partners, but who otherwise are not concerned about the disease.

But there also are many people who believe the stories exaggerating the risks of heterosexual activity. How are these people being affected in their daily lives? There is of course no correct answer. For some, the perceived dangers of AIDS merely provide an excuse to avoid relationships that they would prefer not to have anyhow. But for others, they may cause a number of undesirable results:

- Fear and paranoia about AIDS may impair the healthy sexual activity necessary for the enjoyment of one's adult life.
- Unnecessary or exaggerated alarm sounded by public health officials could adversely affect their credibility, making it more difficult to convince people of a real danger to public health in some future situation.
- People may avoid medical treatment that they need because of a fear of becoming infected with HIV while under treatment. One must wonder how many already have not agreed to necessary surgery or skipped a visit to the dentist because of headlines about persons getting HIV infections from surgeons and dentists. The risk of avoiding or delaying necessary medical attention almost surely is greater than the risk of HIV infection.
- People may delay or avoid the development of relationships that lead to marriage and the raising of families.
- There may be added stress, with resulting health and other problems, for example, sexual dysfunction caused by fears about AIDS among those who actually had no reason ever to be concerned.

There is little that can be done to quantify the damage from the first three concerns. However, it is instructive to examine the differences in mortality rates between single and married people and to compare them with the AIDS risks associated with heterosexual activity.

There are very large differences between observed mortality rates of married persons, as compared with single, widowed, or divorced people. Table 19 compares central death rates by marital status based on population data [48].

Table 19 shows that, except for the male 15–19 year age group, mortality rates for married people are substantially below those for single people. In fact, for many age groups, the rates for single people are more than double those for married people.

These large differences are not necessarily entirely due to a better living environment for those who are married. For example, there may be some antiselection at marriage, with those in poor health being less able to find a marital partner than those in good health. Nevertheless, it is instructive to see how these differences translate into "one-in-a-million" risks. Table 20 shows how many *hours* of delay in marriage result in an additional mortality risk of one-in-a-million, assuming that the entire additional mortality risk of being single would be removed in the event of marriage.

Table 20 shows that, assuming that the mortality differences are due to marital status, even a brief delay in marriage results in an added risk of death of one in a million. Furthermore, for women this table understates the

TABLE 19

CENTRAL DEATH RATES BY AGE GROUP, SEX, AND MARITAL STATUS BASED ON 1980–1981 DATA

Age Group	Mortality Rate per 100,000				
	Total	Single	Married	Widowed	Divorced
Males					
15–19	135.9	134.8	169.4	933.0	400.0
20–24	193.9	211.7	135.9	1,100.0	430.3
25–29	192.5	276.2	123.0	1,120.0	458.5
30–34	192.1	355.3	128.5	1,145.0	500.0
35–39	241.8	592.5	171.7	1,186.5	562.7
40–44	357.6	746.4	275.8	1,200.0	773.6
45–49	581.0	1,238.6	459.1	1,266.6	1,342,0
50–54	932.8	1,991.2	754.8	1,748.4	2,146.9
55–59	1,444.5	2,556.0	1,225.6	2,414.0	3,044.8
60–64	2,195.9	3,398.1	1,926.0	3,473.3	4,154.8
65–69	3,338.9	4,756.3	2,945.4	5,559.8	5,736.1
70–74	4,991.0	7,147.0	4,436.2	7,160.9	7,860.3
75–79	7,323.9	12,872.2	6,235.5	10,567.0	13,034.5
80–84	11,027.0	19,506.0	9,317.1	14,027.0	17,258.6
85–89	16,433.6	26,107.9	14,240.1	18,432.0	19,259.8
90–94	21,981.3	32,226.8	19,333.7	23,250.2	23,000.0
Females					
15–19	51.8	51.5	50.7	270.0	75.0
20–24	60.3	71.9	40.5	274.2	105.0
25–29	67.5	110.7	46.5	282.3	120.3
30–34	82.6	178.7	60.6	285.0	137.6
35–39	122.4	277.9	95.0	300.0	205.7
40–44	195.3	408.8	157.9	381.0	333.1
45–49	319.0	544.0	265.3	587.3	508.1
50–54	496.5	754.0	421.5	776.0	734.8
55–59	746.3	1,160.7	634.6	1,006.8	1,084.3
60–64	1,131.5	1,606.3	939.0	1,478.7	1,573.9
65–69	1,705.2	2,114.4	1,426.6	1,982.9	2,475.8
70–74	2,621.7	3,176.6	2,137.3	2,921.4	3,719.3
75–79	4,132.5	4,960.0	3,409.5	4,314.0	6,340.0
80–84	7,095.9	8,324.6	5,179.4	7,463.0	9,920.4
85–89	11,797.1	14,681.1	7,894.2	12,717.1	12,620.6
90–94	17,983.4	23,584.7	12,717.5	19,202.2	17,000.0

actual risk substantially, because the probability of marriage drops dramatically for them as they move into their 30s, for various demographic reasons.

There does not appear to be any way to measure the effect of AIDS-related stress on mortality and morbidity levels. However, the following comparison is instructive. If a 25-year-old has one evening of sexual activity each week for the rest of his life with someone not in a high-risk group, the risk of AIDS will reduce his life expectancy by less than a single day, assuming that risk levels remain as they are today and that HIV infection

TABLE 20

NUMBER OF HOURS OF DELAY IN MARRIAGE FOR ADDED RISK OF DEATH OF ONE-IN-A-MILLION

Age Group	Male	Female
20–24	116	279
25–29	57	137
30–34	39	74
35–39	21	48
40–44	19	35
45–49	11	31
50–54	7	26
55–59	7	17
60–64	6	13

means certain death (an extremely pessimistic assumption, in this author's opinion, considering the AIDS research currently underway). On the other hand, a 1 percent increase in mortality from heart disease caused by added stress levels would reduce his life expectancy by 18 days.

V. CONCLUSION AND RECOMMENDATIONS

This paper has attempted to show the risk levels associated with AIDS for heterosexuals not using IV drugs. The paper deals with average risk levels; thus while CDC data show that the average risks for blacks is significantly higher than that for whites, individual blacks may have equal or lower risk levels than their white neighbors. Also, risk levels vary geographically. Those in New York or California may have higher risk levels than those in mid-America. Risk levels also vary for various biologic reasons, particularly those relating to other STDs. There also are significant differences in risk levels among the various social classes. Perhaps more than any other disease, the impact of AIDS varies dramatically for different segments of our society.

While the risk of AIDS should not be ignored by those sexually involved with people in high-risk groups, for most heterosexuals allowing the fear of AIDS to create stress and to impair the enjoyment of a healthy sex life and the development of meaningful relationships in all probability will be more costly in terms of mortality and morbidity risk (in addition to the loss of happiness) than the actual risk of AIDS will ever be.

Today AIDS paranoia is rampant. There are thousands of cases of discrimination against those who are suspected of being HIV+. Millions fear

the disease, even though they have no need to do so. Large percentages of the population believe that the disease can be transmitted in ways that all the experts say are impossible. A generation of school children is repeatedly being warned about a risk that for most is far less than other risks they face every day of their lives. Legislation being enacted is based on fear rather than on reason.

This author has the following recommendations for bringing a more balanced view of the AIDS epidemic to the heterosexual population:

1. Try to educate the public that there is a vast difference between what is *theoretically possible* and what is *probable* enough to be of concern. More than ever before, we need a concerted effort to educate the public about risk levels, to bring some rational thinking to public attitudes about AIDS.
2. Emphasize the generally low efficiency of heterosexual transmission in most cases and the fact that few heterosexuals not involved with IV drugs are infected. The statement that "everyone is at risk" may be literally true, in the same sense that men are at risk of developing breast cancer, or people on the ground are at risk of being killed in a plane crash. But the statement implies an equal risk for all, which is far from the truth.
3. Focus heterosexual AIDS education for school children more sharply. There are those who want to use the AIDS epidemic to try to scare all young people into abstinence to reduce unwanted pregnancies and the transmission of other STDs. The objective is commendable; however, falsifying the facts does not work in a free society, as evidenced by the fact that, according to the National Center for Health Statistics, the rate of teenage pregnancy went from 30.6 per 1,000 in 1986 to 33.8 per 1,000 in 1988. Ultimately, falsification destroys the credibility of those on whom the young people should be able to rely for help.

   Instead, the need to avoid sexual activity with those who use IV drugs (and of course anyone else known or suspected to be HIV+) should be emphasized. By making the drug users the pariahs of the teenage community, not only would AIDS education be correctly focused, but also gains probably could be made in the war against drugs.
4. Emphasize the importance of prompt treatment of other STDs. The paper by Holmberg et al. [20] lists genital ulcerative diseases, including herpes and syphilis, as the only unquestioned cofactors in host susceptibility to HIV infection. In 1988, black women, who have a much higher rate of heterosexually transmitted AIDS than white women, had a rate of gonorrhea 21 times as great as that of white women [3]. Similarly, black males, who also have a much higher rate of heterosexually transmitted AIDS than white males, had rates of early syphilis 25 times as high as white males. For black women, the rate of early syphilis was 31 times as great as for white women [10]. Finally, rates of STDs in Africa, where heterosexual conduct is considered to be the primary means of transmission of HIV, are believed to be far higher

than those in the U.S. So the key to reducing the heterosexual transmission of HIV in the U.S. may well involve control of the spread of other STDs to reduce host susceptibility.

5. Stop emphasizing monogamy as a means of reducing heterosexually transmitted AIDS. Most heterosexuals get HIV infections from IV drugs, not sexual intercourse. Most of those who get it from sexual intercourse do so from their primary sexual partner and therefore might well have been better off if they had been *less* monogamous. Monogamy has little value in reducing HIV infections, and emphasizing it shifts the focus away from the real ways in which transmission of HIV can be significantly reduced, namely, safe *homosexual* sex and not sharing IV drug needles or having sexual relations with those who do.
6. Better focus the need for using condoms. For some, particularly young people, they are useful in reducing the risk of pregnancy and STDs. However, for those who can avoid the risks of pregnancy in other ways and for whom other STDs are rare, condoms provide little benefit. On the other hand, for those involved sexually with persons in high-risk groups, the use of a condom may provide a false sense of security, and the real risk levels may be unacceptably high even with a condom.
7. Better educate professionals, including health-care officials, who still have many misunderstandings about the epidemic and what needs (and does not need) to be done to control its spread.
8. Recognize and publicize that the fears about AIDS becoming more widespread throughout the general population no longer need exist. Much was made of the rapid increase in the epidemic; now it's time to allay fears and reduce discrimination and the other injustices that have resulted from the current paranoia.

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DISCUSSION OF PRECEDING PAPER

DAVID M. HOLLAND:

Mr. Plumley presents us with a paper that is provocative and iconoclastic. We are challenged to rethink the conventional wisdom underlying our response to the HIV/AIDS epidemic. Mr. Plumley presents ways for evaluating risk for certain behaviors and for calculating the probability of HIV infection under certain assumptions.

In spite of his arguments, I personally prefer the more conventional approach used by the Public Health Service (PHS). In a *Strategic Plan to Combat HIV & AIDS in the United States* [12], the PHS sets out ten principles that guide the PHS as it formulates policy, sets priorities, and designs programs. Four of these principles are:

- Recognize prevention of HIV infection and AIDS as one of the nation's highest health priorities.
- Focus PHS resources to realize the goal of halting the spread of HIV infection.
- Educate the public about behaviors that promote HIV infection.
- Encourage individuals to cease risky behaviors and to assume greater personal responsibility for their health.

To me, prevention seems a more responsible course. The fact that the rate of growth has slowed down in certain risk groups may be in part attributable to the success of preventive activities rather than evidence that concerns are overstated. The fact that, under certain assumptions, the probability of infection is minuscule is scant comfort to someone who has become infected.

Finally, Mr. Plumley's paper focuses on the AIDS epidemic as it affects heterosexuals. A contrasting perspective is presented in *AIDS in the World 1992* [14], which includes an analysis of trends in the U.S. and Europe prepared by Slutsker, Karon, and Curran of the Division of HIV/AIDS, National Center for Infectious Diseases, Centers for Disease Control, Public Health Service, U.S. Department of Health and Human Services, and by Brunet of the European Center for the Epidemiological Monitoring of AIDS, Hopital National de Saint-Maurice, France. With respect to "Heterosexual Contact," they say the following:

> "Of additional concern in the industrialized world is the increasing incidence of AIDS cases assoicated with heterosexual transmission. Through December 1991, 11,936 cases of AIDS in the United States were reported to be associated with heterosexual contact, representing 6 percent of all cases [4]. In the United States,

in each of the last 5 years, the percentage increase in annual AIDS incidence in this group has been higher than that of any other exposure category. Diagnosed cases in this group increased 41 percent from 1989 to 1990 [7], while corresponding increases were no more than 8 percent in adults in each of the other exposure categories. Projections suggest that AIDS incidence related to heterosexual contact will more than double from 1990 to 1995 [3]. . . .

"Heterosexual transmission is of particular importance among women in industrialized countries. Among women reported with AIDS in the United States, heterosexual contact is the second most frequently reported exposure category and accounts for 34 percent of all reported cases. Most heterosexual contact cases in women are related to sexual contact with an HIV-infected IDU; however, the proportion of women reported exposed through heterosexual contact where the risk of the infected partner was not specified increased from 3 percent in 1983–84 to 16 percent in 1989–90 [2].

"Seroprevalence studies among young women suggest that transmission of HIV is continuing. In the United States, a national survey of childbearing women indicated the overall seroprevalence was 1.5 per 1,000 childbearing women, with rates as high as 5–6 per 1,000 childbearing women in some northeastern states [10]. In Europe, unlinked anonymous HIV serosurveys of delivering pregnant women showed a prevalence rate of 0.27 percent in Paris, 0.20-0.33 percent in industrialized regions of Italy, and 0.14 percent in London [8], [11].

"Among disadvantaged adolescents (aged 16–21 years) applying for work in the Job Corps in the United States, the rate of infection was only slightly lower among women than men (3.2 vs. 3.7 per 1,000); among those aged 16 and 17, seroprevalence was higher among women (2.3 per 1,000) than men (1.5 per 1,000) [15]. It is unlikely that injection drug use among young women would explain this low male-to-female ratio, because 2 to 3 times more male than female high-school students report injecting drugs and sharing needles [5]. Rather, the narrow gap between HIV infection prevalence in young men and women is consistent with the epidemiology of traditional STDs, suggesting that heterosexual transmission may have contributed to the relatively high rates of infection among females in this group.

"Heterosexual transmission of HIV may be linked both to drug use and STDs. Genital ulcerative diseases, such as chancroid, syphilis, and perhaps other STDs, have been noted to facilitate acquisition and transmission of HIV [9]. In the United States, the incidence of primary and secondary syphilis increased 61 percent from 1985 to 1989, with the greatest increase (176 percent) in African-American women [13]. Spread of syphilis, as well as gonorrhea and chancroid, has been linked in some situations to use of illegal drugs, especially crack cocaine, through drug-related high-risk sexual behaviors, such as having sex with multiple partners for money or

drugs [1] [6]. Thus, approaches to limit heterosexual transmission of HIV, syphilis, and other STDs in the United States may require additional resources for programs for STD-infected sex workers, drug users, and their sexual contacts."

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LESLIE JOHN LOHMANN:

Mr. Plumley's paper is one that has been long overdue; the dissemination of information to the public has been slanted and, at times, wrong. I disagree, however, with his apparent conclusion that, since the risk of heterosexual transmission (especially female to male) is minuscule, one needs to take less care. A friend's miserable death over several months convinced me that this is a disease for which it is worth having a zero probability of infection!

Mr. Plumley's conclusions about the danger of a dependence on the use of condoms are valid; avoiding sexual contact with infected persons is the best way to avoid infection. If condom use reduces care in partner selection, then, as Mr. Plumley concludes, its use will increase the risk of infection, not decrease the risk. Mr. Plumley observes that condoms are not foolproof; condoms reduce the risk of infection, but do not eliminate the risk. This observation reminds me of how viruses were first detected; infected material passed through a ceramic filter and remained infectious; latex hardly seems adequate.

Many of the known characteristics of viruses can lead to the same conjectures that Mr. Plumley makes in his paper. There are several additional ones that I would like to add:

- Increasing T-cell count in infected persons will lead to more rapid progression of the disease.
- Recurrent herpes may be the single most important, controllable disease leading to rapid progression of the disease.
- The incubation period of the disease is directly related to the number of viruses transmitted and the existence of a disease that is neutralized by T-cell activity.
- The long incubation period of the disease makes it difficult or impossible for an infected individual to recall with precision the circumstances under which the infection was contracted.

Finally, Mr. Plumley's implication that a woman who chooses a sexual partner from the homosexual community has only a remote risk of infection

is not supportable by his analysis. The further expansion of his conjecture to include those who are not "needle-sharing IV drug users" is dangerous. Choosing partners from groups who themselves may have high-risk partners is high-risk, regardless of the personal IV drug use of the intended partner, needle-sharing or otherwise.

The Human Immunodeficiency Virus

The HIV is an extremely small organism with no motile power of its own. As with other viruses, HIV can generally destroy only one particular type of cell (the "target" T-cell). However, the reproductive cycle is so short (once a target cell encounters an HIV) that mutations can and do occur rapidly. If the mutation is minor, the virus will continue to infect the same kind of cell and probably survive until the host dies. Major mutations, those which change the virus so it can no longer infect the same kind of cell, lead to the "death" of the new virus, unless the new target cell exists in the environment in which the new virus finds itself. A major mutation also may affect the environment in which the new virus can survive; its current environment may be inhospitable.

Within a hospitable environment, the HIV can exist indefinitely. The human bloodstream seems to be such an hospitable environment, allowing viruses to exist, undetected and non-infecting for years. Absent a target cell in which to reproduce, the HIV will not reproduce.

Developing the Disease

The HIV kills T-cells, not infected individuals. The so-called "opportunistic" diseases are responsible for the HIV-infected individual's death. For the symptoms to progress, there must be enough HIV in the host's bloodstream to make it virtually impossible for T-cells to play their role in fighting the "opportunistic" diseases.

The HIV cannot move on its own. Once in the host's bloodstream, it floats around until it encounters a T-cell. It enters the nucleus of the T-cell, takes over the genetic material, reproduces, and kills the cell, freeing second-generation viruses into the bloodstream. During this stage, the infected T-cell becomes a target for the immune system; the immune system produces antibodies; and the standard tests that identify HIV will become serum-positive. Before this time, the standard tests will be negative (assuming perfect tests).

The encounter with a T-cell is a probabilistic event. The T-cell cannot "see" the HIV and the HIV cannot find the T-cell. Simply put, the probability of symptoms developing (the end of the incubation period) is related to the number of HIV present in the bloodstream (the q) and the number of T-cells in the bloodstream (the "exposure"). Progression to symptoms can therefore be retarded by reducing either the q or the "exposure." Conversely, anything that increases either of these will shorten the incubation period.

Before the onset of symptoms, medical treatment of disease of people infected with the HIV should be confined to methods that do not stimulate T-cell production. This is particularly important among HIV-infected people who become ill with a disease for which the body's first line of defense would be T-cell production. This will not decrease the number of virus, but it will decrease the exposure and the probability of the virus encountering the target T-cell, reproducing and destroying it.

One disease that is prevalent in the community at large also is prevalent in the community of HIV-infected persons: recurrent herpes. This disease stimulates the production of T-cells (the "exposure") and, hence, increases the probability of symptoms developing. Since acyclovir will control recurrent herpes without T-cell stimulation, it is my opinion that it should always be used, once HIV infection has been confirmed.

Specific Comments

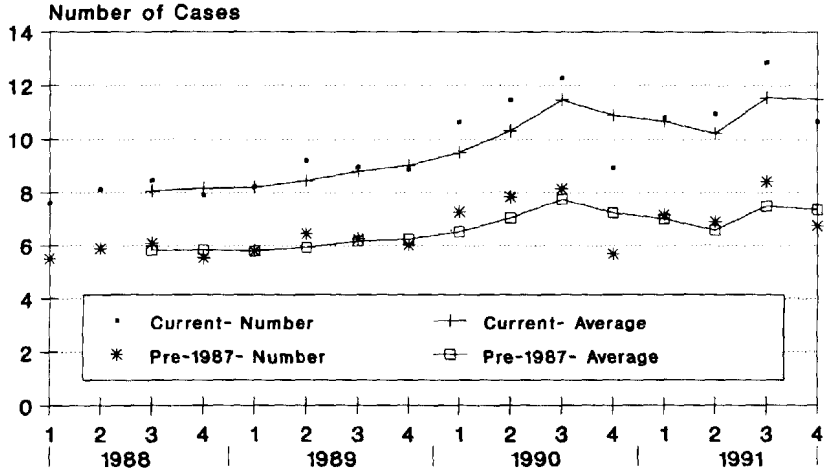
I have graphed Mr. Plumley's Table 1 to assist in its interpretation (see Figure 1).

The major defect in the classification of cases according to the manner in which the person became infected is the reliance on the infected person's memory. Even where memory may be reliable, fear of censure and the like may lead to other than candid results. Mr. Plumley's effort at allocating the "heterosexual contact" class is a good first effort.

The efficiency of transmission is directly related to the characteristic that HIV cannot move independently. HIV moves with the bodily fluids in which it is contained. Heterosexual intercourse typically results in fluids moving toward the female and not the male, supporting Mr. Plumley's statistically based assertion that the female-to-male transmission efficiency is very low. In addition, the HIV is reportedly "fastidious," meaning that it does not survive long outside a hospitable environment. This would support Mr.

FIGURE 1

AIDS CASES BY REPORTING DATE



"Current" is current definition
"Pre-1987" is prior definition

Plumley's determination that even the male-to-female transmission efficiency is statistically quite low.

Mr. Plumley's analysis of risk levels for multiple partners is flawed. He uses the probability function:

$$i \times [1 - (1 - p)^n]$$

where

i = the probability that one's sexual partner is infected
p = the probability of infection from a single act of sex with an infected partner
n = the number of sexual acts during the period.

The probability i should not be applied here. One's sexual partner is either infected or not. In the situation in which the concerned partner is *not* infected, there are only two possibilities:

- The sexual partner is not infected. The probability of infection in a monogamous relationship with this partner is deterministically 0, regardless of the "boredom" factor. Any amount of sexual activity with additional partners increases the risk of infection for *both*.

- The sexual partner is infected. The i in the above formula becomes identically 1. The risk of infection is decreased maximally (to the neighborhood of zero) by avoiding sexual contact with this partner, accepting the premise that infection by other-than-sexual means in negligible.

Again, the most important element in remaining uninfected is the avoidance of infected partners. Mr. Plumley's observations concerning condom use remain valid.

Repeated exposure to additional virus increases the number of virus available for random contact with the target cells. This probabilistically decreases the length of the incubation period, the period before the onset of symptoms. It is unlikely that repeated exposure "wears" down the body's ability to fight off the virus, other than the cumulative effects of the destruction of T-cells.

The virus has a very definite life cycle. Its lack of motility leads to the observation that, the fewer virus that are present in an infected person, the less likely that any particular bodily fluid will have virus in it. Assuming that an individual has been infected with only a single HIV that has not yet reproduced, the probability of that virus being in transmitted bodily fluid is negligible. In the later stages, as symptoms develop, most transmitted bodily fluids will contain the virus.

Mr. Plumley's comments concerning "intelligent or caring" IV drug users falls far short of the reality of IV, or any other, drug use. Regardless of native intelligence or concern, drug use seriously erodes the drug user's judgment. Just as the HIV-infected person's recollection of how and when he became infected is likely to be defective, so also is the IV-drug-user's recollection of whether he has ever shared a needle. All the factors that impair memory of the source of HIV infection memory also affect the answer to the question "Do you share needles when you use IV drugs?" plus the additional factor that the person answering the question has a vested interest in responding with the "right answer," a sexual encounter. All drug users should be sexually avoided because of this memory/judgment issue. There is no such thing as "an honest addict."

The CDC and the gay community have had a direct impact on the public understanding of the disease and tolerance of infected individuals. In the early stages of the epidemic, both groups published clearly unfounded statements, regardless of whether they were true. This has led to a significant amount of distrust and, hence, fear. As with all relationships, this initial

impression will be hard to dispel, even as the CDC begins to make statements that have a studied foundation.

Mr. Plumley's paper provides a valuable step into uncharted waters. I hope that it leads to more analyses upon which founded statements about the disease can be made. I think that his single most important observation is that choice of partner is far more important than the use of condoms. I hope that others seriously question his conclusions about additional sexual partners before taking any action, since I believe that he has made a statistical error in the analysis of monogamous versus non-monogamous sexuality.

Finally, I repeat what I said at the beginning. The progress of this disease is far more miserable than any of the others mentioned for comparison in the paper. That combined with the possibility that one could infect loved ones leads to my conclusion that one is served best by reducing the probability of infection to 0.

BRADLEY P. CARLIN

I congratulate Mr. Plumley on a careful and cogent paper on a difficult and controversial subject. There are certainly serious shortcomings in the public's understanding of AIDS, and the risk involved in a single sex act for a typical heterosexual may well be comparable to those associated with many other everyday activities. The author is to be commended for promoting the notion of a continuum of risk, rather than the simpler classification (often desired by the public) of activities as either "safe" or "unsafe." Still, I find myself uncomfortable with several of the author's conclusions and recommendations for public health policy.

Because of the intimate nature of the disease, data pertaining to the AIDS epidemic are often scant and unreliable. CDC data are likely among the best available, but even here, well-documented reporting delays would lead one to believe that recent reports of new AIDS cases are underestimates. New case projections have indeed proved to be too high, but this is partly because the progression from HIV infection to AIDS takes longer than originally thought, due to improved drug therapies and the continuously evolving nature of the epidemic itself. Moreover, AIDS models and projections continue to improve as more sophisticated analytic techniques are brought to bear (see, for example, Lange, Carlin, and Gelfand*). Regarding the level of risk

*LANGE, N., CARLIN, B.P., AND GELFAND, A.E. "Hierarchical Bayes Models for the Progression of HIV Infection Using Longitudinal CD4 T-Cell Numbers" (with discussion), *Journal of the American Statistical Association* 87 (1992): 615–32.

from heterosexual contact, the African AIDS epidemic, where cases are distributed nearly equally among the sexes and there is little evidence of IV drug use or homosexuality, suggests a higher risk of heterosexual transmission. In the U.S., if a patient indicates both heterosexual contact and IV drug use on the CDC form, the transmission is allocated to the latter cause by the CDC surveillance definition. In fact, since the behaviors traditionally associated with HIV risk are generally covert, investigators often assume that certain behaviors are occurring even when they are *not* indicated by the patient. Finally, most of the longitudinal studies having an opportunity to document conversion to HIV-positive status have been done on extremely specific subpopulations (for example, homosexual men in San Francisco who meet certain eligibility criteria), so that understanding transmissions in "the general public" is problematic.

The author recommends reducing the emphasis on monogamy and condom use in public health education efforts and instead focusing on more careful screening of potential sex partners. By eliminating sexual contact with high-risk individuals (homosexuals, bisexuals, and IV drug users), the risk of HIV infection can be virtually eliminated. But this advice reminds me of the old joke,

> *Patient (running into doctor's office, bending his arm):* "Doctor, it hurts when I do this!"
> *Doctor*: "So don't do that!"

Clearly the advice, "Don't have sex with persons likely to be HIV-positive" is sound, but how can this information be reliably elicited? One can't tell by looking whether a potential partner is a homosexual, bisexual, or IV drug user, and questioning the candidate seems a dubious strategy in those cases that actually matter. Given these problems with the conditional viewpoint (that is, where one assumes perfect knowledge of the candidate's risk group status), the prudent heterosexual might well adopt an *un*conditional approach to the problem of partner selection, thus spreading the total risk over a vastly larger number of potential partners. This latter approach appears to form a logical foundation for our current public health strategy. Despite the problems in the practical implementation of this strategy, encouraging condom use among sexually active persons still seems enormously sensible. The author's arguments against condom use and on "the negative side effects of the AIDS education" seem speculative and not terribly compelling.

On a related note, the author's eighth and final point in his Section V recommendation list correctly stresses the need "to allay fears and reduce discrimination and the other injustices that have resulted from the current paranoia." But in line with his conditional approach to partner selection, the third point in this same list suggests stressing to young persons the need "to avoid sexual activity with those . . . *suspected* to be HIV+" (emphasis mine). If we further encourage "making the drug users the pariahs of the teenage community," wouldn't homosexuals and bisexuals become the next logical candidates for pariah status? Discrimination issues aside, such an approach would appear to *increase* paranoia, not reduce it.

The author observes that the typical heterosexual may be worse off if the fear of AIDS has a negative impact on the likelihood or timing of a future marriage. But it is widely argued that the increased mortality associated with being single is due to a riskier lifestyle—perhaps including unprotected sex with a multitude of partners. Marriage is probably not the "cause" of improved mortality, but merely an associated variable. Hence while I agree that any attempt to motivate responsible behavior through scare tactics would be counterproductive, young persons should probably understand that heterosexual promiscuity is not without HIV risk.

Finally, the author's approach is reminiscent of that of the insurance industry as a whole to the problem of AIDS: simply try to screen out persons in high-risk groups and absorb whatever risk remains. From an aggregate standpoint, this is perhaps a sound strategy, but it may not be appropriate for any given individual (for example, a young person residing in an urban area, a group for which AIDS often ranks with the leading causes of death). In summary, it may not be possible to be too cautious when making public education recommendations concerning AIDS, a disease that so far has proved 100% fatal.

PAUL O. KIRLEY:

The author is to be congratulated for his continuing and interesting analysis of the AIDS epidemic in terms of the transmission modes of HIV infection and their probabilities. However, three minor items seemed to detract somewhat from the effectiveness of some of the paper's otherwise convincing arguments.

First, the entries in Table 3 for heterosexual males do not agree with the 0.0% columns of Table 4. Direct recalculation of the entries in the two

tables reveals that the latter table was calculated by using the author's more recent estimate of $p = 0.000625$ for males, whereas the former used the same value of p (0.00125) for both sexes, as had been done in his earlier paper. A more explicit comment on the comparability of the two tables would have been appreciated; alternatively, Table 3 could have reflected the new male assumption for p in the same fashion as does Table 7.

Second, the paper's formula for the probability of HIV infection that is used to develop Table 4 (that is, the formula that incorporates the factor f) may have been excessively simplified. The factor f is defined to be "the percentage increase in the probability of infection for each additional act of sex with the same infected partner," but the formula seems to assume an instantaneous average increase in the probability of infection, rather than a separate increase for each act, as implied by the definition of f. The following formula for the probability of HIV infection is, I think, more in keeping with the author's definition of the factor f:

$$i\left\{1 - \prod_{j=1}^{n} [1 - p(1 + f)^{j-1}]\right\}$$

To evaluate the magnitude of the difference between the two formulas, the $f = 0.5\%$ columns of Table 4 have been recalculated using the above formula and are summarized for comparison with the corresponding values in Table 4 as follows:

RATIO OF RISK FOR MULTIPLE VERSUS SINGLE PARTNERS
0.5% INCREASE IN PROBABILITY OF INFECTION PER SEXUAL ACT WITH SAME PERSON

Number of Sexual Acts	From Table 4 of Paper	Using Above Formula	From Table 4 of Paper	Using Above Formula
	Heterosexual Female Partner Not High-Risk		Heterosexual Female Partner IV Drug User	
20	0.96	0.97	0.96	0.96
50	0.92	0.91	0.91	0.90
100	0.86	0.84	0.84	0.81
200	0.80	0.72	0.75	0.68
500	0.83	0.67	0.71	0.57
	Heterosexual Male Partner Not High-Risk		Heterosexual Male Partner IV Drug User	
20	0.96	0.96	0.96	0.96
50	0.90	0.90	0.90	0.89
100	0.83	0.80	0.82	0.79
200	0.73	0.65	0.71	0.63
500	0.62	0.42	0.57	0.39

As shown in the table, the differences resulting from the two formulas are of roughly the same magnitude as the differences attributable to sex. This casts some doubt on the validity of the use of an average increased value of p equally for each act. In fairness, however, I note that similar comparisons for homosexual men (Table 5 of the paper) do not reveal any significant differences resulting from the two formulas.

Finally, there is an obvious misstatement in the last sentence of the "points worth noting about Table 6." No probability can be the reciprocal of another probability unless both are certainties, which is clearly not the case in the situation of Table 6.

ADRIAN PININGTON AND JANINA SLAWSKI:

An article accepted by an actuarial journal will be used by other actuaries and members of the general public as an actuarial reference. Although there will always be room for differences in opinion within our profession, we believe that it is dangerous to publish an article that may be thought of as the view of the actuarial profession on AIDS, without eliciting comment from experts in the field, and adding whatever caveats are necessary to ensure that, first, no information presented is incorrect, and second, personal observations are identified as such. We have a number of reservations about the conclusions drawn in this paper and the methods used to derive them. Some of these are set out below. We hope that our comments will be taken in a serious light, and that the decision to publish this paper in its current form will be given careful consideration.

Mr. Plumley confines his analysis to the U.S., which has, so far, experienced a predominantly homosexual and intravenous-drug-user epidemic. He states that most heterosexual AIDS cases can probably be traced to a bisexual male, hidden drug-needle-sharing, or anal intercourse. He ignores the observed experience in Africa, where these factors are not a significant influence in the transmission of AIDS. While there has been some evidence that there is a higher rate of transmission between African lives as compared to other races, this is not sufficient to explain all the heterosexual spread in Africa. Mr. Plumley's contention that there is negligible heterosexual spread in the U.S. is subject to debate. According to World Health Organization (WHO) statistics, in 1985 about 3 percent of total U.S. reported AIDS cases were heterosexual. By 1990 nearly 8 percent of total cases reported were heterosexual. This alone suggests that the premise on which Plumley has built his paper is unsound.

Mr. Plumley states that the actual reported number of AIDS cases in 1990 was well below the projections made by actuaries. He appears to be working on the assumption that there is about 10 percent underreporting and that the reporting process is improving. However, in 1990, it was reported that the CDC believed that, in many ways, AIDS case reporting was getting worse, not better. The CDC revised down to 85 percent from 90 percent its estimate of the number of AIDS deaths being reported.

The formulas on page 349 of the article assume that the probability, i, that one's partner is infected, is constant. In reality, it will vary by geographic region, time and the sexual behavior patterns of the group from which one chooses one's sexual partner(s). The implications of this point for the spread of HIV are crucial. Epidemiological mathematical theory can be used to demonstrate that the pattern of numbers infected over time for a heterogenous population, with several homogeneous subgroups, will rise in steps. Looking to Africa, we find prima facie evidence that we should not be lulled into complacency because of observed flattening of the reported AIDS statistics.

STEPHEN B. GWIN:

I thank Mr. Plumley for his paper because it stirs thoughtful consideration of this serious social issue; however, I am very concerned that his paper will be potentially harmful in the hands of people who do not understand the assumptions he made. They may very well see his paper as promoting promiscuity as safer than monogamy.

The potential for harm is especially great because the conclusions are listed at the beginning of the paper without the assumptions. For example, on page 00 it is stated: "For heterosexuals, if the likelihood of transmission increases only slightly with repeated sexual activity with the same partner, risk levels will actually decrease for sexual activity with multiple partners, as compared with the same amount of activity with one partner." It is 15 pages later before the reader learns that the assumptions include: "The probability of one's partner being infected is the same regardless of whether the person is engaging in sexual relations with a single partner or with multiple partners." This assumption is the only way that this conclusion can be true since, as Mr. Plumley states: "And of course no heterosexually transmitted cases come from monogamous relationships with uninfected partners."

In Tables 14–17, it is assumed "that the probability that one's sexual partner is HIV+ is the same for all three groups" (monogamous, semi-monogamous, multiple partner). This assumption may be true for a portion of the U.S. society, but not for most. Mr. Plumley quotes from the November 1988 issue of *American Psychologist* as evidence that 37 percent of husbands and 29 percent of wives have had extramarital sexual relations. This means 63 percent of husbands and 71 percent of wives have not had extramarital sexual relations. For virtually all these monogamous persons, the assmption of equal probability is not valid; therefore, the conclusion that "the number of sexual partners makes little difference in the risk of HIV infection" cannot apply.

A monogamous relationship of uninfected partners involves no risk, while sexual activity with multiple partners involves risk of HIV transmission. The paper by Holmberg et al. quoted by Mr. Plumley includes the following sentence: "Thus, sexually active persons should be cautioned that, to our knowledge, there are no nonsusceptible persons and that any single sexual encounter may lead to HIV transmission." This is sound advice even if the efficiency of transmission of HIV by heterosexual contact is low. With millions of heterosexual contacts each day, even a very low transmission rate among people with multiple partners means some are being infected every day with the consequence of enormous suffering and misery in the future for themselves and often for their unborn children.

The risk of contracting HIV is compared in the paper to various risks of life. Several examples are provided, demonstrating that most of us take "one-in-a-million" risks without much concern. However, in many other situations, we go to great effort and expense to eliminate risks that are in the order of magnitude of "one-in-a-million." For example, a recent newspaper article told of the National Highway Traffic Safety Administration evaluating whether to require General Motors to spend as much as $1 billion to recall pickup trucks suspected of having unsafe gas tanks [1]. The Insurance Institute for Highway Safety estimates that the $1-billion expense will reduce the rate of fatal side-impact collisions with fires by 2.8 accidents per year per million vehicles. Why should such a huge expense be incurred if risks on the order of "one-in-a-million" are so insignificant? In 1990, there were 0.03 deaths from airline accidents per 100 million passenger-miles flown, yet numerous individuals refuse to fly because they are afraid of the

risk [3]. The point is that evaluation of acceptable risk in situations involving one's well-being is subjective and cannot be reduced only to statistics. Because of the great misery and suffering that HIV brings to a person, I believe our profession should be very cautious in quoting statistics that downplay the risk of HIV.

A recent report from the Centers for Disease Control and Prevention provides good reason for actuaries to be careful in minimizing the risk of HIV transmission from multiple sexual partners. Of 1,011 pregnant women who registered for prenatal care at a public health clinic in western Palm Beach County, Florida, 5.1 percent tested positive for HIV, and 21 percent of those who tested positive "had two to five partners, didn't use crack, had never had a sexually transmitted disease and had never had sex with a partner they knew was at high risk" [2]. Actuaries have a social responsibility when interpreting statistics related to the public's health. In the case of HIV transmission, I believe our social responsibility requires us to avoid speculation about practices that may harm many individuals.

It would be a shame if Mr. Plumley's paper were to cause some people to expose themselves to the risk of HIV when they would not have otherwise done so. An obviously unintended effect of this paper could be to increase the likelihood of heterosexual HIV transmission. I seriously doubt whether any heterosexual who is HIV+ would find any consolation in learning that his risk was "one-in-a-million or less."

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ARNOLD N. GREENSPOON:

Mr. Plumley's paper is a positive contribution to the available literature on the AIDS epidemic. Especially important is his elucidation of the role that a basic understanding of contingent probability should play in setting public policy.

It is unfortunate that in his desire to give the reader a feel for the comparability of various risks, the author is a little hasty in quoting National Public Television. I believe that there is no evidence that either smoking one cigarette or spending one hour in a coal mine constitutes a "one-in-a-million" risk. I can only conjecture that this factoid was deduced from statistics that smoking x cigarettes or spending x hours in a coal mine adds $x/1{,}000{,}000$ to the mortality risk. There is no reason to assume that these risks are linearly related to the number of cigarettes smoked or hours underground. Nor is this a trivial matter. Government bans on many valuable substances have been based on exactly this fallacy.

In discussing the risks of the fear of AIDS, Mr. Plumley states that "People may delay or avoid the development of relationships that lead to marriage and the raising of families." The author has provided no demonstration for this impression. Therefore it would be remiss not to hypothesize exactly the opposite: The fear of AIDS may cause people to develop specifically the types of relationships that lead to marriage and families. Although we are all entitled to opinions on these matters, they should remain beyond the professional scope of the actuary in the absence of any evidence. Mr. Plumley's paper gives us a taste of the contribution that actuaries can make to society in this and other areas: Working in conjunction with social scientists, we can create morbidity and mortality models based on their behavioral assumptions.

GEORGE E. IMMERWAHR:

Both in this paper and in his article "The Magic of Risk and the Risk of Magic" [5], Mr. Plumley endeavors to convince us that the risk of infection with the AIDS virus in heterosexual intercourse is extremely remote and that therefore the admonitions for "safe sex" and the use of condoms are misleading the American public. He then goes on to say that the excessive concern over AIDS resulting from heterosexual intercourse, particularly from "casual sex"—that is, sex with persons other than one's spouse or regular partner—could be unduly interfering with normal sex attitudes and activities and therefore causing emotional stress, leading in turn to shortened life expectancy or even death by suicide. He admits that for homosexuals and IV drug users and their partners, the risk of AIDS is a serious problem, but claims that for most of us it is a risk far too remote to be of concern.

I have virtually the same data on HIV transmission that Mr. Plumley uses in his calculations, and except for one particular I do not question either his

information sources or his calculation results. But there are implications in his writing to which I take exception; these are the main points of this discussion.

The one particular that I do question is his assumption that the rate of male-to-female transmission of the AIDS virus among heterosexuals is only twice as great as that of female-to-male. The fact is that we do not know the ratio, except that the male-to-female risk is almost certainly greater than the female-to-male. A paper by Ickovics and Rodin [4] mentions several studies of the risk of male-to-female transmission, one of which suggested that it might be as much as 12 times the risk of female-to-male.

But the fact remains that AIDS is a serious heterosexual risk for females relative to the risk for men. The data show that though only 2 percent of male AIDS victims had become infected heterosexually (the remaining 98 percent being mostly homosexuals or IV drug users), the corresponding proportion among women is at least 30 percent. To the extent that men are the sexual initiators, which is still usually the case even in these days of sexually liberated women, one can view AIDS as having been imposed on women by men.

While I hope the AIDS epidemic has virtually peaked in the U.S., as Mr. Plumley claims, it is feared that the epidemic is far from peaking in the Third World, particularly in Africa where almost all AIDS is transmitted heterosexually, defying the idea that heterosexual transmission is improbable. Sub-Saharan Africa and some Caribbean countries such as Haiti are described by AIDS researchers as "pattern II countries" because of the high degree of sexual promiscuity there, and demographer Caldwell [2] has described the social structure that underlies African promiscuity.

Yet American sexual promiscuity falls short of what Caldwell describes only by degree, and it is disturbing to many to see how our promiscuity has increased over the years. Those of us who were already adults before World War II have observed tremendous change in patterns of sexual behavior. Even though I personally welcome the advances in contraceptive technology and the *Roe vs. Wade* decision (which I hope will be allowed to stand), I am sure that there is far too much obsession with sex in today's society. The demand for sexual satisfaction, and also the stimulation of this demand by the media, are so great that many males feel free to resort to rape if persuasion fails, and many marriages are undermined when people are led to seek sex with persons other than their spouses. Persons of my generation had sexual urges as strong as those of subsequent generations, but past

society condoned far less casual sex than today's society, and yet the failure to satisfy our urges did not drive us to suicide.

The most unfortunate consequence of today's casual sex is not AIDS but unwed pregnancy and childbearing. About 70 percent of African-American children born today, and about 20 percent of white, are born to unwed mothers and face not only poverty but also many other problems far more serious than do children of married parents. In analyzing black infant mortality (which is twice as high as white), Ahmed [1] points out the unmarried status of a mother is an even more significant predictor than the mother's age of her child's early death.

Sports heroes like Wilt Chamberlain [3] claim to have had sex with great numbers of women without even giving a thought about the children they are likely to have fathered in the process. Does this bother us? Does it bother us that inner-city boys compete to see who can first get a girl pregnant, and then go on impregnating one girl after another? Does it bother us that the media are aggressively stimulating these and other forms of sexual obsession? These are things we should worry about, rather than the chance of committing suicide for not having enough sex.

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HARRY H. PANJER AND X. LIN*:

Mr. Plumley's provocative article provides useful information about many aspects of the AIDS epidemic as it affects heterosexuals. However, using some rather questionable calculations, he makes recommendations for public

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policy. Our criticism is with the logic used in the calculations and the resulting conclusions. We believe that the two key formulas used are flawed, the first empirically and the second both theoretically and empirically. Therefore, the resulting conclusions cannot be supported by the calculations.

Mr. Plumley's main thesis is that heterosexual activity has only minimal exposure to the risk of HIV infection, even with a large number of partners. He argues that such exposure is insignificant when compared with other risks in life. Furthermore, he speculates that efforts at reducing the HIV risk may raise other risks, such as those created by anxiety.

The current conventional wisdom is that the riskiest activities for HIV infection are receptive anal intercourse and sharing of needles in intravenous drug use. In each case, simple prevention procedures are available. Clearly, educational programs to encourage abstinence from these practices or to encourage safer practices have the potential for saving many lives. Mr. Plumley argues that any programs aimed at heterosexual vaginal intercourse, even with many sexual partners, are misguided since the risk of transmission is very low.

In coming to his conclusions, he carried out a number of calculations. His Table 3 purports to compare the elevation of risk of multiple heterosexual partners over that of a single partner. He states that "even for as many as 100 different sexual partners, there is only a 6 percent increase in risk for heterosexuals, as compared with the same amount of sexual activity with one partner."

Implicit in his calculation is the assumption that a sexual partner, monogamous or not, is selected randomly from the population at large. We believe that the selection of a partner by a monogamous person is generally not done from the population as whole but from the subpopulation of persons with similar values and sexual behavior. Similarly, for persons choosing multiple sex partners, the selection of partners is generally from the non-monogamous subpopulation. Therefore the probability of choosing a seropositive partner is very different for monogamous and for non-monogamous persons. Thus, the increase in risk of HIV infection for a non-monogamous person when compared with that of a monogamous person is much larger than 6 percent. Selection of sex partners is not random; the risk is small for the monogamous portion of the population. Clearly, the population cannot be divided into two groups: one group of persons who are inherently monogamous and another group who are inherently non-monogamous. However, the probability of selecting a seropositive partner must be highly correlated

with the level of sexual activity as measured by the number of partners that a person chooses. Thus the term i in Mr. Plumley's formulas varies dramatically based on the number of partners.

In Mr. Plumley's two key formulas following Table 3, a critical assumption is that the probability of transmission depends highly on the number of sexual acts, even with the same person. This is in direct contradiction to the findings of Peterman et al. [2], who find that transmission probability is unrelated to the actual number of sexual contacts for monogamous partnerships (where one partner was infected by transfusion) ranging from a single to several thousand sexual contacts. The *number of sexual partners* is far more important than *the number of sex acts*. This is more important in Mr. Plumley's first equation following Table 3, since the probability should be independent of n, the number of sex acts, whereas in the second equation, n could refer to the number of different sex partners.

The study by May [1] provides further guidance on the probability of sexual transmission *per partnership*. In the study of 80 (virtually all monogamous and all sexually active) heterosexual couples for which one of the partners was infected through blood transfusion, May reports that 2 out of 25 males with seropositive female partners became infected, while 10 out of 55 females became infected from their seropositive male partners. These numbers suggest a male-to-female transmission rate of about 0.2 per partnership over a relatively few years. The corresponding female-to-male rate is then about 0.1 per partnership.

If we apply these probabilities to persons with many sexual partners, each with multiple sex acts, it is not difficult to imagine that a single seropositive male can easily infect several female partners. Even using the rate of 0.2 per partnership, a seropositive male with as few as 5 partnerships over a lifetime could expect to infect at least one partner.

An epidemic grows if, on average, infected persons infect at least one other person. Based on May [1], the conventional wisdom that multiple sex partners increase risk significantly is valid. This situation is analogous to the situation with male homosexuals where the spread of HIV was very rapid in the subgroup of those with many partners. With heterosexuals, the rate of infection *per contact* or *per partner* is much lower, and so any resulting epidemic will grow much more slowly. The lower rate of infection cannot be used to eliminate the possibility of continued HIV infection in the nonmonogamous heterosexual population. It is wise to separate all heterosexuals into subgroups according to the number of sex partners. Separating out the

monogamous subgroup leads to higher estimates or risk exposure for the non-monogamous groups.

May [1] also observes that only one of the 12 cases of HIV transmission involved anal intercourse, while all included vaginal intercourse. This counters Mr. Plumley's speculation that most heterosexual infections are caused by anal intercourse and not by vaginal intercourse.

The second of Mr. Plumley's formulas following Table 3 also suffers a serious theoretical flaw. The probability of choosing at random an infected partner should increase as the number of infections in the subpopulation from which sexual partners are selected increases. This is due simply to the effect of saturation. Sexual partners are probably drawn from relatively small subpopulations, based on socioeconomic, cultural, ethnic, geographical, or other criteria. Thus the factor i increases exponentially initially in small subpopulations. There is good evidence of local outbreaks of HIV in small communities.

Mr. Plumley makes excellent points about the risk of crossover to the heterosexual population through IV drug needle-sharing and from bisexual activity. Because of the high transmission rates for these activities, it should be expected that the largest proportion of observed cases among females resulted from IV drug use. This does not mean that the smaller number of heterosexual cases (31 percent) is not significant and will not grow. May [1] suggests that this problem is analogous to one of multiplying zero (a very small probablility) by infinity (a very large population). Clearly, the number of heterosexual cases could easily become very large. On the other hand, it could also remain small. A high degree of uncertainty remains.

Mr. Plumley is correct in observing that the choice of partner is most important. Avoiding sex with IV drug users will reduce risk dramatically. He also argues that "the choice of sexual partner is far more important than the use of a condom . . ." since it is not useful for sex with an uninfected person and since "the risk may still be too high to be acceptable in most circumstances." Clearly the first part of the statement is correct. However, Mr. Plumley completely dismisses the role of the condom in the reduction of transmission probabilities for sex with an infected partner. His argument is analogous to the argument that seat-belt usage in cars results in more deaths and injuries because the act of using the seat belt induces increased risk-taking behavior. The absurdity of this statment is now well-documented. Note that in the May [1] study, none of the 12 couples for which transmission occurred had ever used a condom.

From a public policy perspective, campaigns aimed at non-monogamous heterosexuals can be most effective if they focus on reducing the number of sexual partners, choosing sexual partners carefully and using condoms as a preventive measure especially when a person has multiple partners and any of those may be IVD users or bisexuals.

Mr. Plumley argues that only the second of these measures (choosing carefully) is important. We believe that Mr. Plumley's conclusions are fundamentally wrong and that public policy should dictate prevention through all three measures.

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MICHAEL J. COWELL:

In discussions of Mr. Plumley's previous papers and articles on AIDS and the HIV epidemic, I have congratulated him on his pioneering work in analyzing the epidemic by risk group. In his latest paper, however, I believe that Mr. Plumley has drawn from his statistics various observations and conclusions that are not supported scientifically.

I would certainly agree with his concern about public misunderstandings of the epidemic. However, I am even more concerned that his seemingly well-documented statistics given an aura of reality to a number of his more arrant conclusions.

Fortunately, the readership of Mr. Plumley's paper will be confined largely to the actuarial profession in which the overall level of awareness of the epidemic is already so high that his statements will not be taken seriously as an exhortation to throw caution to the wind as far as the personal risk of HIV infection is concerned.

In summary, I find nothing convincing in his paper to suggest that the public health community's concern about the epidemic and its cautions to avoid infection are at all unwarranted, unfounded or exaggerated.

1. State of the Epidemic in North America

Has the HIV epidemic reached a plateau?

Mr. Plumley cites the slowing of newly reported AIDS cases in 1990 and 1991 as evidence that the epidemic is in decline.

Like him, I am pleased to see that AIDS cases as reported to the Centers for Disease Control (CDC) in the U.S. and the Laboratory Center for Disease Control (LCDC) in Canada are slowing down from 1990 to 1991 and 1992. This trend portends a lower ultimate level of AIDS in the two highest risk groups in North America than projected by earlier researchers, including Walter Hoskins and myself.

However, the current stream of new AIDS cases is not a measure of today's epidemic. Rather, given the average of 8–10 years between initial HIV infection and the development of full clinical AIDS, it is more nearly a reflection of the epidemic of the mid-1980s.

If, as is hoped, the epidemic is self-limiting, then eventually a point will be reached at which the rate of death exactly offsets the incidence of new HIV infection. Thereafter, deaths will exceed new infections, and the infected population will decline to the point of extinction. A less optimistic scenario would be for the prevalence of HIV infection to settle down to some fairly constant percentage of the population.

As seen from analysis of the few long-range studies of HIV infection, there is some evidence that the epidemic within some populations of male homosexuals may have reached a plateau. A similar trend may be taking place among IV drug abusers, but it is far more difficult to track trends of this, or any kind, in a group that, by its very nature, does not manifest health concerns.

2. Trends in Heterosexual HIV and AIDS

While the above trends give some limited encouragement that these two major subsegments of the epidemic in the U.S. may be reaching plateaus, it is too early to assert that HIV is peaking among heterosexuals.

Even Mr. Plumley acknowledges that the number of heterosexual transmissions is increasing, but he adds that it ". . . is showing evidence of leveling off in the near future." The data he presents show no evidence of such a trend. To the contrary, sentinel studies by the CDC and U.S. military recruiting units suggest that the epidemic is still in its early stages, especially among adolescents and young adults.

In this connection, it is useful to observe that in the U.S., the 15,221 cases through September 1992 reported to have been transmitted through

heterosexual contact approximate the total cases from all risk groups through year-end 1985. Because of the progression pattern from initial infection to AIDS, the ratio of HIV infections to reported AIDS cases is highest in the earliest stages of the epidemic.

Thus, while the estimate of approximately four HIV infections for each case of reported AIDS might be appropriate for the aggregate of all causes of transmission at this time in the epidemic, the ratio is likely much higher for heterosexual transmission, where the epidemic is in an earlier stage. Thus, 15,000 AIDS cases could translate to anywhere from 100,000 to 200,000 heterosexual HIV infections.

3. *Implications for Heterosexual Behavior and Attitudes toward the Epidemic*

Based on his formula for the probability of HIV infection for a given number of sexual acts, Mr. Plumley concludes that:

> " . . . if the likelihood of transmission increases only slightly with the same partner, risk levels will actually *decrease* for sexual activity with multiple partners." [The italics are his.]

However, his formula is highly dependent on two variables, p and f, the probability of infection from a single sexual act with an infected partner and the increase in that probability for each additional act with the same partner, respectively. The first variable is based on little more than highly speculative guesses, and the second, even by Mr. Plumley's own admission, cannot be reasonably estimated. Unlike many other statistics that have been developed over the past several years to measure the epidemic, neither of these factors is susceptible to ready validation. Any conclusions drawn from such analysis should, therefore, be viewed as little more than speculation, certainly not the basis for personal action or public policy.

Mr. Plumley goes on to make several additional statements with respect to the infection risk to heterosexuals that, in my view, are pure conjecture and are not supported by his data. The following two are among the more egregious:

> "A person should not be concerned about who his or her sexual partners had been with previously, unless it appears that the partner had had a regular sexual relationship with someone in a high-risk group. . . ."

> ". . . for many, the fear of AIDS may present more of a mortality risk than AIDS itself."

4. Risk Tolerance and Aversion—Individual Assessments

From his assertion that "It will never be possible to eliminate risk," Mr. Plumley concludes that

> "To try to do so, while ignoring the secondary effects, is counterproductive and merely takes the focus away from the real problems of our society."

It is not clear what Mr. Plumley considers those "real problems" to be. For many in the public health arena, especially in cities already overburdened with the care of AIDS patients, each additional case becomes a "real problem." For those individuals with HIV, their infection is probably the most "real problem" of their lives.

As to his point about the impossibility of eliminating risk, this is certainly not a sound argument for not wanting to "measure, manage and communicate" its impact. In the case of HIV infection, management of the risk means, for most people, wanting to reduce the risk virtually to zero.

Admittedly, there is a range of tolerance of risk. Even with the same knowledge of the risks involved, some people will, for example, engage in sky-diving, while others will avoid commuter flights in small planes, and others still will avoid air travel completely. Indeed, utility theory is founded on the existence of differential preferences for the outcome of events; it underlies the demand curve for insurance.

The following assertion by Mr. Plumley is at once presumptuous and preposterous:

> ". . . for most heterosexuals allowing the fear of AIDS to impair the enjoyment of a healthy sex life and the development of meaningful relationships will be more costly in terms of human mortality and morbidity than the risk of AIDS."

It presumes a knowledge of the risk/reward relationship of the AIDS-risk/sexual-enjoyment equation across the heterosexual spectrum that Mr. Plumley does not—and probably cannot—document. While he does not attempt to do so, in my opinion it is not possible for him or anyone else to equate the cost of the fear of AIDS and the risk of AIDS itself.

In citing the CDC statistics on heterosexual AIDS through the end of 1991, Mr. Plumley notes that: "Only 9,413 were from sexual activity with an HIV+ person." *Only* 9,413! By year-end 1992 that number will be *only* 13,000 or so, not including another 3,000 infected through heterosexual contact with a person born in a "pattern II" country.

No doubt the risk/reward relationship took on a wholly different meaning in retrospect for each of these more than 16,000 heterosexuals when learning for the first time that he or she had become HIV infected.

5. HIV Risk—A Societal Assessment

Mr. Plumley claims that:

> "We must recognize and publicize that AIDS *never* is going to become widespread throughout the general population, so long as reasonable health standards are followed."

The emphasis on "never" is mine, not Mr. Plumley's. "Never" is a long time in terms of human epidemics and, if nothing else, a reading of Mr. Plumley's paper and this discussion should attest to the point that people will have different interpretations of what constitutes "reasonable" health standards. The growing epidemics of other sexually transmitted diseases over the past two decades—chlamydia, herpes, gonorrhea—do not give much encouragement that "reasonable health standards" are being followed as widely as most of us would like to believe.

To his credit, Mr. Plumley does confirm the hypothesis that HIV infection is not a disease that targets only homeosexuals and IV drug abusers. His conclusions about its potential spread, however, seem based almost exclusively on the North American experience. In eastern equatorial Africa, which most epidemiologists cite as the epicenter of the disease, it has spread uniformly among the male and female populations. In some countries—notably, Kenya, Malawi, Uganda and Zambia—as many as 30 percent of all adults are believed to be infected.

A recent study* by the Harvard AIDS Institute estimates that there may already be as many as 3.7 million children in Africa orphaned by losing one or both parents to the disease. Another study in the *Journal of the American Medical Association*† reports 18,500 children similarly orphaned in the U.S. and projects that this number will exceed 80,000 by the year 2000.

It is, of course, important to point out the major difference in the progress of the epidemic in Africa from that in the West. The pattern of the epidemic's spread in North America is largely an accident of how it was introduced. Had it been introduced heterosexually in the first place, the disease might now be showing a more uniform spread among the male and female populations (classified by the World Health Organization as "pattern II" transmission) as is the case in a number of African and Caribbean countries. In this connection, it will be instructive to follow the trend of the epidemic in

*MANN, JOHATHAN M. *AIDS in the World*. Cambridge, Mass.: Harvard University Press, 1992.

†MICHAELS, D., AND LEVINE, C. "Estimates of the Number of Motherless Youth Orphaned by AIDS in the United States," *Journal of the American Medical Association* 68, no. 24 (December 23/30, 1992): 3456–61.

a country like Japan, where the disease has been traced principally to men returning from visits to prostitutes in other Asian countries, notably, Thailand.

6. Implications for the Actuarial Profession

For the past decade or more, AIDS and the HIV epidemic have presented the life and health insurance industry in North America, indeed throughout the world, with a number of challenges. The actuarial profession has lived up to its responsibility to "measure, manage and communicate" the financial implications of the AIDS risk by projecting the impact of the epidemic on insurers, helping develop suitable underwriting standards, establishing appropriate pricing, reserving and risk capital standards, and analyzing AIDS claims. Mr. Plumley has made a major contribution to this effort in his prior papers and articles.

Throughout its work in this regard, the profession has been faced with numerous examples of needing data that either are not available or, if they exist at all, do not have the neatness and precision that most actuaries are accustomed to using. In each case in which data were unavailable or uncertain, actuaries took the prudent approach of erring on the side of conservatism. This has served the industry well, limiting the extent of antiselection through appropriate underwriting precaution and establishing prudent margins for the AIDS risk in pricing, reserving and setting risk capital standards. No less prudence would seem to be in order in approaching the risk from a personal standpoint.

I do not expect that Mr. Plumley will retract any of his claims, not even those that I have cited as the more extravagant. Nevertheless, I do hope that in his review of this discussion, he will at least acknowledge that some of these claims are based on little more than highly speculative guesses as to certain underlying parameters that cannot reasonably be estimated, and that they should therefore be regarded as not much more than conjecture, and certainly not as the factual basis for personal or public policy decisions on the risk of HIV infection.

MARK D. J. EVANS:

Mr. Plumley has written an excellent paper concerning the AIDS epidemic. He develops a demonstration that "the added risk from engaging in sexual activity with multiple partners, as compared with the same number of acts with the same partner, is very small." This is a reasonable conclusion

based on the assumptions used. There are, however, other factors not directly addressed that can reduce the risks associated with monogamous sexual activity and increase the risk associated with multiple sexual partners.

The paper assumes a sexual partner's HIV status is unkown. In a monogamous relationship, this is not necessarily the case. In a monogamous relationship initiated before the onset of the AIDS epidemic where neither partner has shared needles with a third party or received a transfusion prior to blood supply testing, there is no material risk. Also, one's HIV status can be obtained via testing, which is now readily available. Thus it is possible to be in a monogamous relationship practically risk-free of HIV.

For more contagious STDs, the probability of infection from having multiple sexual partners is much higher than for having one partner as demonstrated in Mr. Plumley's Table 6. Some of these STDs in turn increase the level of efficiency of transmission of HIV. Similarly, to the extent that the use of condoms can reduce the spread of other STDs, they can indirectly reduce the spread of HIV.

Mr. Plumley argues against imprisoning those known to be HIV+ who engage in sexual intercourse. On the other hand, society has a right to expect each member to act responsibly (as many people who know they are HIV+ do). Remedial action of some form should be taken against those who do not act responsibly.

KRZYSZTOF OSTASZEWSKI:

Mr. Plumley has done a model job of analyzing the AIDS risks. This is a work of outstanding quality and originality.

In my discussion I merely would like to address the author's concern expressed in his statement: "Today AIDS paranoia is rampant." The author brings strong statistical evidence to justify his statement. My concern is that expression of risks only in statistical terms may not fully represent the economic reality that insurance firms will have to address when dealing with the AIDS epidemic issue. To illustrate my idea, let me quote from a recent, most revealing article of Nancy Rose [2], discussing airline safety: "Airline safety analyses appear to have garnered a disproportionate share of major journal pages in recent years, relative to more significant risks. This national preoccupation with airline safety may provide the ultimate explanation for the high safety standards maintained by U.S. carriers and the immense improvements in air safety over time."

What may be needed in either case is a model of risk including the human perception of risk. Traditional statistical models cannot factor in human perception, due to its vagueness and imprecision. I do humbly submit, however, that some fuzzy sets methods proposed in my work [1] may be useful in modeling AIDS contingencies.

Furthermore, the market response to public perceptions of air travel risks has been improvement in safety standards. The education remedies suggested by the author in his evaluation of public perception of the AIDS epidemic are most certainly valid. I would add, however, that in a manner similar to the way the airlines handled public risk perception, insurance firms and the health-care industry can learn to accommodate the public needs.

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(AUTHOR'S REVIEW OF DISCUSSIONS)

PETER W. PLUMLEY:

First, I thank the many who responded to my paper. Even though there are disagreements with specific points, it is always rewarding to learn that a paper has been read and has created enough interest to generate a significant level of response.

However, I must admit to some disappointment in the discussions. My paper had two principal purposes:

- To analyze the implications of the low efficiency of transmission of HIV by penile-vaginal sexual intercourse. These included (1) frequency of tertiary transmissions, (2) distribution of HIV transmission between primary and other partners, (3) change in risk levels for multiple versus single partners and consequent effectiveness of monogamy as a means of prevention, and (4) effectiveness of "safe sex" campaigns. While many statments had been issued concerning these matters, they generally were simplistic and did not reflect the unique nature of the AIDS epidemic. To the best of my knowledge, no one had sought to analyze these matters from a purely theoretical viewpoint by combining available data with mathematical principles. It was hoped that by undertaking such an

analysis, it would be possible to recommend ways to sharpen the present focus of AIDS education and prevention efforts.

- To examine risk levels as compared with other risk levels in our daily lives, to place the risk of HIV infection in better perspective. It does little good to say "reduce the risk of HIV transmission to zero"; to do so means not only to give up all sex, but also to absolutely avoid any other activity (for example, going to the dentist, being in a crowd of people one of whom might stick one with an infected needle, having a blood transfusion, and so on) that could conceivably result in HIV infection. Therefore, putting the risk of HIV transmission in proper perspective is essential if one is to conduct one's life in a rational manner.

Unfortunately, some of the discussants fail to understand these objectives, so that some of the discussions demonstrate more emotion than actuarial analysis. This is regrettable; however, it is hoped nevertheless that the many others who read the paper will understand its objectives and benefit from it.

Regarding the comments of the discussants, I particularly thank Mr. Holland, who has himself done so much work on the AIDS epidemic, for his comments, especially those on the connection between the heterosexual spread of HIV and the presence of other STDs. As I say in my paper, "the key to reducing the heterosexual transmission of HIV in the U.S. may well involve control of the spread of other STDs to reduce host susceptibility." This is particularly important for the black community, which has a far higher rate of heterosexually transmitted AIDS cases than the white community and also far higher, and rapidly increasing, rates of other STDs.

However, I must admit to some puzzlement over Mr. Holland's discussion. He states that "to me, prevention is the more responsible course," as if I were suggesting that heterosexuals do not need to be concerned about prevention. To the contrary, the paper suggests more effective ways to achieve prevention, while recognizing that the risk for most heterosexuals is extremely small. He certainly is correct that the small risk is scant comfort for those who have become infected; however, the same can be said for anyone who takes any type of remote risk and is unfortunate enough to become a victim nevertheless.

I also am puzzled by his characterization of the chapter from *AIDS in the World 1992* as "a contrasting perspective." I find little in Mr. Holland's excerpts that is not either beyond the scope of my paper or in general agreement with it.

Mr. Lohmann makes a worthy contribution to the paper by providing additional information about the nature of the AIDS epidemic. However, there are several points with which I must disagree.

- He criticizes my analysis of the relative risks in multiple- versus single-partner relationships. While he is correct with regard to a particular individual, I am looking at the issue on a collective basis. Thus, people of a certain age and risk classification are said to be subject to a force of mortality of a certain amount, even though each individual will either live or die during the time period involved.
- He states that "Mr. Plumley's implication that a woman who chooses a sexual partner from the homosexual community has only a remote risk of infection is not supportable by his analysis. The further expansion of his conjecture to include those who are not 'needle-sharing IV drug users' is dangerous." This makes no sense to me. First, I make no reference to women who choose sexual partners from the homosexual community—in fact, it seems to me to be an oxymoron—by definition, a woman's sexual partner must be bisexual or heterosexual, not homosexual. In addition, I do not understand the second sentence, taken with the first.
- He then makes the arbitrary statement that "choosing partners from groups who themselves may have high-risk partners is high risk, regardless of the personal IV drug use of the intended partner, needle-sharing or otherwise." Yet he offers no data to support his statement, nor does he demonstrate any inaccuracy in the formulas that I use to analyze the risk of such matters.
- Finally, he states that "one is best served by reducing the probability of infection to zero." Because there is no way to *totally* eliminate the risk of HIV infection during a sexual encounter, he is in effect saying that *all* sexual activity should be eliminated until a cure for AIDS is found. Not only is this obviously impractical and unrealistic, it places far too much emphasis on AIDS as a risk factor in a life that is full of risk, whether we like it or not.

Mr. Carlin comments on possible inaccuracies in the classification system used by the CDC. I agree that this certainly is a problem. The hierarchal system tends to classify some cases of heterosexual transmission as arising from homsexual contact or IV drug use. On the other hand, homosexuals and IV drug users tend to try to hide their lifestyle, and studies have shown that they can be quite successful.

Mr. Carlin also criticizes my approach to prevention and education; however, in doing so he seems to be implicitly making some of the assumptions that I try to refute in my paper, namely, that tertiary infections are a significant factor in HIV transmission and that having multiple partners increases the risk of HIV infection.

He further states that we should teach young people that heterosexual promiscuity is not without HIV risk. Yet he offers no evidence that multiple partners increase such risk (and I know of no study that has shown such an increase). Furthermore, unlike that for other STDs, most cases of HIV transmission from heterosexual contact arise from a primary sexual relationship, not a promiscuous one.

Mr. Kirley adds several valuable technical comments to my paper, for which I thank him. However, I disagree with his final comment that "no probability can be the reciprocal of another probability unless both are certainties, which is clearly not the case in the situation of Table 6." To the contrary, if one assumes an infinite number of sexual contacts, the probability does become a certainty, and so I believe that my analysis is correct.

Mr. Pinington and Ms. Slawski correctly comment on the large differences between the AIDS epidemic in the U.S. and that in Africa. They also discuss the underreporting of AIDS cases to the CDC as being a reason why the number of cases reported has been far below projections made only a few years ago. However, even by inflating the numbers to allow for the 15 percent underreporting suggested by them, earlier projections still are far too high. For example, in a sidebar commenting on my article "Has the AIDS Epidemic Peaked?" [2], a spokesperson for the CDC stated that "by the end of 1992 we expect a total of 365,000 [AIDS cases], including the ones we have right now. . . . These are Public Health Service and CDC projections." Yet the actual number reported to the CDC by the end of 1992 was about 255,000, which is 110,000 less than projected, even though the projection was made only 18 months earlier. Such a difference cannot be explained away by underreporting—nor can the differences from Table 2 of my paper.

Mr. Pinington and Ms. Slawski also express concern about the rising percentage of AIDS cases that are classified as from heterosexual contact. This increase is not surprising, considering that most of these cases arise from sexual contact with infected IV drug users and that it takes a period of years for the disease to spread first to the IV drug users and then to their

regular partners. Their comparison with the situation in Africa further emphasizes the need to keep the efficiency of transmission low by maintaining good health standards and reducing levels of other STDs, so that there is no real chance for the disease to spread to any degree within the heterosexual population.

Mr. Gwin is concerned that my paper could be potentially harmful in the hands of those who do not understand my assumptions. However, a paper published in a professional journal is intended for readers who will read it in its entirety and will understand the assumptions.

He also criticizes my conclusions about the relative risk levels of single-partner versus multiple-partner situations, on the basis that many single-partner situations involve monogamous relationships with uninfected partners. While this is true, there are others that involve monogamous relationships with *infected* partners. While the risk factors may be inappropriate for situations in which the infectivity of the partner is known, I believe they are correct on a collective basis—a limitation that is true for any mortality statistic.

He also points out that there are situations in which there is great concern about "one-in-a-million" risks. He refers to the possible recall of General Motors trucks at a cost of about $1 billion and asks "why should such a huge expense be incurred if risks on the order of 'one-in-a-million' are insignificant?" The answer may center around politics and emotion, rather than reason. In fact, the same money spent on such matters as prenatal care probably would be much more effective in saving lives.

But Mr. Gwin misses the point. Life is not simply a matter of reducing the risk of HIV infection, and a good sexual relationship may well be sufficiently beneficial both physically and psychologically that it adds more to one's life expectancy than the risk of HIV infection subtracts. Furthermore, since most HIV transmissions from heterosexual contact arise from primary, and in many cases monogamous, relationships, what is Mr. Gwin proposing—that we do away with sex altogether until a cure or vaccine is found for AIDS?

Mr. Gwin then cites a *USA Today* report that about 1,011 pregnant women in Florida, 11 of whom allegedly seroconverted without having used IV drugs or been involved with sexual partners whom they knew to be high risk. He then states "In the case of HIV transmission, I believe our social responsibility requires us to avoid speculation about practices that may harm many individuals. It would be a shame if Mr. Plumley's paper were to cause

some people to expose themselves to the risk of HIV when they would not have otherwise done so. An obviously unintended effect of this paper could be to increase the likelihood of HIV transmission."

I find several problems with Mr. Gwin's analysis.

(1) I place little credibility on a newspaper article based on only 11 HIV-positive people, knowing that the story made news precisely because it was so unusual.

(2) I fail to see why we are not fulfilling our "social responsibility" when we analyze risk levels for various practices, regardless of whether these risk levels apply to everyone. We certainly have done so with regard to smoking.

(3) My paper may expose some to HIV when this would not have occurred otherwise; however, the intended effect is to *improve* AIDS education and prevention to make it more effective and on balance to *reduce* the spread of HIV by heterosexual contact.

Mr. Greenspoon criticizes my quote from National Public Television about the risk of certain activities on the basis that the figures may be fallacious. I point out that in using these figures I specifically stated that I made no attempt to verify their accuracy, but merely used them to illustrate that most of us take "one-in-a-million" risks every day of our lives.

Mr. Immerwahr comments on some of the social problems in our society, all of which I agree with, but which were beyond the scope of my paper. He also states that the efficiency of male-to-female transmission of HIV may be far more than twice that of female-to-male. He may be correct; however, I point out that this does not necessarily indicate that the efficiency of male-to-female transmission is greater than I suggest in my paper. Instead, it may demonstrate that the efficiency of female-to-male transmission is less than I assumed, and in fact I suggest in the paper that this might well be the case.

The Panjer and Lin discussion is very disappointing. Dr. Panjer has distinguished himself for his prior work on the AIDS epidemic; yet the discussion is filled with misquotes from my paper and poor analysis of cited references.

They refer to the studies by Peterman et al. and by May as providing support for their thesis that the number of sexual partners is more important than the number of sexual acts. (It should be pointed out that in fact there is only one study, that of Peterman et al. The May article is simply a report on the Peterman study, with a few additional comments added; it includes

no original research.) They state that my assumption that transmission probability depends on the number of sexual acts "is in direct contradiction to the findings of Peterman et al., who find that transmission probability is unrelated to the actual number of sexual contacts for monogamous partnership (where one partner was infected by transfusions) ranging from a single to several thousand sexual acts."

It is true that the Peterman study does not show a relationship between the number of sexual acts and the probability of transmission of HIV. However, several facts must be pointed out regarding the study:

1. There were only 10 females and 2 males who seroconverted during the study—hardly a large enough sample to warrant drawing any conclusions about this point.
2. Because the group being studied comprised all blood transfusion recipients, the average age was much higher than that of most AIDS victims. Thus, at least with respect to age, the group was atypical of AIDS victims.
3. There are in my opinion two very plausible reasons why there was no correlation between the number of sexual acts and the probability of seroconversion. (1) At the ages involved, the frequency of sexual activity tends to diminish for many people. Furthermore, the frequency also depends on the health of the individuals, which varies widely for people in their 50s and 60s. It seems quite likely that those who were in the best health had the highest level of sexual activity. On the other hand, those whose health was failing to some degree, *possibly because they were approaching the later, more infectious stages of HIV/AIDS*, would have less sexual activity. (2) The average age of the 10 women who seroconverted was 62, while the average age of those who did not was 54. Studies have suggested that older people may be more susceptible to HIV infection, given the same amount of exposure to the virus. These two factors could easily account for the lack of correlation, particularly for such a small sample.
4. Referring to data on other sexually transmitted disease and their effect on the efficiency of HIV transmission, Peterman states that "these data indicate that the risk of HIV transmission is not simply a function of the number of sexual contacts with an infected person." I make the same point in my paper. However, he makes no claim that the likelihood of transmission is related to the number of partners rather than the number of sexual contacts—indeed, he is hardly in a position to do so,

because his study related solely to monogamous couples (with the exception of one woman). This point is further emphasized in May's commentary on the Peterman paper. May states "we must be careful in extrapolating from this possibly atypical data set, and it seems reasonable to assume that, in general, transmission probablity may depend to some degree on the duration of a partnership and/or the number of contacts."

Dr. Panjer and Mr. Lin state that "the study by May [1] provides further guidance on the probability of sexual transmission *per partnership*" (emphasis by Dr. Panjer and Mr. Lin). They then go on to describe the study, which actually was done by Peterman et al. (and which does not relate to multiple partnerships). They use the probability demonstrated by Peterman of male-to-female transmission over a period of up to 10 years in *monogamous* relationships of 0.2 to claim that "it is not difficult to imagine that a single seropositive male can easily infect several female partners." This logic requires that the transmission probability of 0.2 demonstrated for long-term relationships would apply equally to a "one-night-stand" or short-term relationship (which neither Peterman nor May claim to be true).

Dr. Panjer and Mr. Lin make the flat statement that "the number of sexual partners is far more important than the number of sex acts," based on their analysis of the Peterman paper, even though as mentioned above the paper related only to a study of monogamous couples. I know of no study to back up that claim. On the other hand, Chiasson et al. [1] examined data for 1,389 men according to (among other variables) whether they had had 10 or more sexual partners in the last year. In the words of the authors of that paper, there was "no significant association between HIV-1 infection and . . . reporting 10 or more partners in the past year."

Dr. Panjer and Mr. Lin further state that "Based on [the May paper], the conventional wisdom that multiple sex partners increases risk significantly is valid." This conclusion is totally unwarranted—as already mentioned, the May paper is simply a review of the Peterman paper, and both are based on a study of monogamous couples and do not attempt to draw any conclusions about the multiple- versus single-partner risk levels.

They then state that "this situation is analogous to the situation with male homosexuals where the spread of HIV was very rapid in the subgroup of those with many partners." In fact, it is not analogous at all, as I point out in Table 4 and the accompanying text of my paper. The reason is the higher efficiency of transmission among homosexuals, and the greater likelihood

that one's partner is HIV-positive in a multiple-partner situation (which is related to the higher efficiency of transmission).

Dr. Panjer and Mr. Lin comment that May observes that "only one of the 12 cases of HIV transmission [reported in the Peterman study] involved anal intercourse, while all included vaginal intercourse." They then go on to state that "this counters Mr. Plumley's speculation that most heterosexual infections are caused by anal intercourse and not by vaginal intercourse." I make no such statement in my paper. To the contrary, I state that "there is no way of accurately determining what proportion of sexual acts by women are anal rather than vaginal." I then go on to state that, although "some significant portion" of female AIDS cases reported as heterosexual contact might be from other than penile-vaginal sex (either anal sex or IV drug use not detected by investigators), it appears that "a significant portion of the cases so reported did in fact arise from penile-vaginal sexual activity."

They speak of the number of females with AIDS arising from IV drug use. They then state that "This does not mean that the smaller number of heterosexual cases (31 percent), is not significant and will not grow. May . . . suggests that this problem is analogous to one of multiplying zero (a very small probability) by infinity (a very large population)." In fact, May's comment relates to the issue of transmission by casual contact, where, although there may have been no cases reported, in theory the risk may be greater than zero, with the number of contacts being enormously large. I fail to see the relevance of this in analyzing the issue of transmission by sexual contact, where risk levels and frequency of sexual contact can be estimated from existing data.

Dr. Panjer and Mr. Lin allege that "Mr. Plumley argues that any programs aimed at heterosexual vaginal intercourse, even with many sexual partners, are misguided since the risk of transmission is very low." In fact, I make no such argument. To the contrary, I give several recommendations to make AIDS education efforts among heterosexuals more effective and to reduce high-risk behavior while at the same time keeping risk levels in proper perspective.

They are critical of Table 3 of my paper, stating that "implicit in his calculation is the assumption that a sexual partner, monogamous or not, is selected randomly from the population at large." They then point out why the probability of choosing an HIV-positive partner might be different for a non-monogamous than for a monogamous person and appear to use this

point as a criticism of the paper. However, this criticism is invalid, for several reasons:

1. Table 3 is based, not on an *implicit* assumption, but on the *explicit* assumption the probability of having an infected partner is the same. The paper then goes on to discuss why there might be differences in this probability. In fact, a major point of the paper is that it is the *nature* of the sexual partners, not the *number* of partners, that determines the risk. To criticize a formula relating to the *number* of partners, because the *nature* of the partners might be different, simply shows a lack of understanding of the assumptions made in the formula.
2. They postulate that a sexual partner chosen from the non-monogamous subpopulation is more likely to be HIV-positive than one chosen from the monogamous subpopulation. However, in doing so they are in effect using circular reasoning, in that they are making an assumption of the very point they are trying to prove. I know of no evidence that this claim is correct.
3. They further claim that my formulas following Table 3 are flawed because the probability of choosing at random an infected partner would increase as the number of infections from the subpopulation from which the partners are selected increase. It certainly is true that the proportion of persons infected will be much higher in certain subpopulations; however, Table 3 illustrates the effect of this by comparing the relative risk levels for persons with partners who are IV drug users (that is, where the proportion of people in the subpopulation who are infected is very high), with that for people whose partners are not from the high-risk groups and therefore where the proportion infected is low. The table shows that the increase in risk levels for multiple versus single partners is about the same for the two groups—in fact, is slightly *lower* for the persons choosing partners from the high-risk group. (Of course, the *absolute* level of risk is much higher for those choosing partners from the high-risk group, but that is not the point.)

Dr. Panjer and Mr. Lin state that "Mr. Plumley completely dismisses the role of the condom in the reduction of transmission probabilities for sex with an infected partner." I do no such thing. To the contrary, I state that "certainly if two people are going to engage in sexual activity in any event, the proper use of a condom will reduce whatever risk would otherwise exist of transmission of AIDS and other STDs, and of unwanted pregnancy."

Dr. Panjer and Mr. Lin then claim that my concern about the side effects of urging the use of condoms is analogous to the argument that seat-belt use induces increased risk behavior—an argument that has been refuted by studies. It is true that there is an analogy. In both cases there is a risk that can be reduced, but with the offsetting possibility that there will be adverse behavior change that may to some degree offset the risk reduction. In the case of seat belts, the risk reduction from using the seat belt on the average exceeds the added risk from the behavior change. In the case of condom usage, the situation is unclear, and so in my paper I illustrate the effect of various levels of behavior changes. (It might be mentioned that several years ago one of the officials at the CDC involved with the AIDS program was asked "if one of your children was going on a date, and you had a choice of urging the use of a condom, or of a seat belt, which would you urge?" He replied "a seat belt.")

Finally, Dr. Panjer and Mr. Lin state that "Mr. Plumley argues that only [choosing sexual partners carefully] is important." Once again, I make no such statement. I do, however, correctly point out that a sensible choice of sexual partner is the single most important way to prevent HIV infection, and that another important step is to keep one's own body free of diseases that can increase the possibility of HIV transmission, in the unfortunate event that one's partner should be HIV-positive.

They argue that the use of condoms is important as well and point out that none of the 12 couples in the May (actually, Peterson) study had used condoms. Do they really expect monogamous, married couples in their 50s and 60s to use condoms? They have hit on the problem with urging the use of condoms: most heterosexually transmitted HIV infections come from long-term relationships, not from "one-night stands." Yet it is unrealistic to expect people in such long-term relationships to use condoms very much (except for birth control, or unless they know that one of them has some type of STD), which is why the emphasis on choice of sexual partner and personal health is a better approach to the prevention of heterosexually transmitted HIV.

Mr. Cowell's discussion is particularly disappointing. There is a cynical saying in the legal profession, to wit: "If the facts are on your side, argue the facts. If the facts are against you, argue the law. If the law is against you, pound the table." Mr. Cowell is a distinguished actuary—yet his discussion is laced with comments that seem to be more a demonstration of "table-pounding" than a rational analysis of my paper. In fact, in his entire

lengthy discussion he does not cite a single reference to contradict any of the 51 I cite, nor does he demonstrate any inaccuracies in any of the many formulas and tables in my paper.

He states that "I am . . . concerned that his seemingly well-documented statistics give an aura of reality to a number of his more arrant conclusions." Yet nowhere in his discussion does he provide any data to refute any of mine.

He states that "Fortunately, the readership of Mr. Plumley's paper will be confined largely to the actuarial profession in which the overall level of awareness of the epidemic is already so high that his statements will not be taken seriously as an exhortation to throw caution to the wind as far as the personal risk of HIV infection is concerned." Yet nowhere in my paper do I state that people should "throw caution to the wind"; to the contrary, the paper offers a number of constructive suggestions for reducing the heterosexual transmission of HIV through AIDS educational efforts based on an improved understanding of risk levels.

He states that "Mr. Plumley cites the slowing of newly reported AIDS cases in 1990 as evidence that the epidemic is in decline." I make no such statement in my paper. To the contrary, I state: "Because of the substantial period between HIV infection and the development of clinical AIDS, a look at the number of reported AIDS cases is not sufficient to determine whether the number of persons becoming infected is declining."

Mr. Cowell correctly states that the ratio of HIV-positive people to those with AIDS is greater in the earlier stages of an epidemic, and then he uses this fact to claim that "15,000 AIDS cases [from heterosexual contact] could translate to anywhere from 100,000 to 200,000 heterosexual HIV infections." Although Mr. Cowell appears to be using this as evidence of my lack of understanding of the seriousness of the heterosexual AIDS epidemic, if one allows for the "Cowell conservatism," which he admits to at the end of his discussion, and if one quantifies this conservatism by reference to Table 2 of my paper, which shows that Mr. Cowell projected 1992 AIDS cases at about double the number that actually developed (more than double, using his "pessimistic" scenario), the actual number of HIV-positive non-IV-drug-using heterosexuals actually might be about 50,000 to 60,000. This is roughly equivalent to the assumption that I have been using in my papers of one HIV-positive non-IV-drug-using heterosexual per 5,000 population.

Mr. Cowell correctly quotes my paper as stating that ". . . if the likelihood of transmission increases only slightly with the same partner, risk levels

will actually *decrease* for sexual activity with multiple partners." He is critical of this statement for two reasons:

1. He claims that my estimate of p, the probability of infection from a single sexual act with an infected partner "is based on little more than highly speculative guesses." To the contrary, the very low efficiency of transmission of HIV by heterosexual contact has been documented in a number of studies, some of which are referred to in my two AIDS papers. If I have erred, it has been by overstating, rather than understating, the efficiency factors, particularly for female-to-male transmission.
2. He claims that the variable f, which is the increase in the level of efficiency for additional sexual acts with the same partner, cannot be reasonably estimated. I agree, and so state in my paper. Mr. Cowell seems to have missed the point that the factor f is an *assumption*, not a determinable variable, and the statement that he quotes begins "*if* the likelihood of transmission increases . . ." (emphasis added). My paper lists five reasons why the level of efficiency might increase over time with the same partner; however, no claim is made that it would or would not in any given instance.

Mr. Cowell categorizes two statements as "egregious," on the basis that they are not supported by my data. The first of these is that "a person should not be concerned about who his or her sexual partners had been with previously, unless it appears that the partner had had a regular sexual relationship with someone in a high-risk group." Yet the paper includes several tables that demonstrate the truth of this conclusion and contrast it with the homosexual situation where, because of the higher efficiency of transmission and the much higher proportion of HIV-positive people in the group, the previous partners make a significant difference in risk levels.

The second statement characterized as "egregious" by Mr. Cowell is my claim that ". . . for many, the fear of AIDS may present more of a mortality risk than AIDS itself." Even though the mortality risk from AIDS can be quantified to some degree, there appears to be no good way to quantify the mortality risk from AIDS-related stress and other AIDS-related factors. It is precisely for this reason that the statement that Mr. Cowell criticizes uses the qualifying words "for many" and "may." However, there is ample evidence that most heterosexuals face only negligible risks from AIDS. It also is clear that there is much public paranoia about the epidemic and that it has affected the lives of many. I have talked with more than one woman who chain-smoked while telling me that she fears developing relationships

with men because of her fear of AIDS. There must be many others like her. Can Mr. Cowell, who is fully familiar with the risks of smoking, seriously suggest that these women might not be able to cut down on or eliminate their smoking habit if they were in a loving relationship with a man? My statement may not be quantifiable, nor do I claim it to be—but to characterize it as "egregious" is inappropriate.

Mr. Cowell characterizes as "presumptuous and preposterous" my statement that ". . . for most heterosexuals allowing the fear of AIDS to impair the enjoyment of a healthy sex life and the development of meaningful relationships will be more costly in terms of human mortality and morbidity than the risk of AIDS." Yet it is clear that for most heterosexuals, the risk of AIDS is extremely remote. If those for whom the risk is remote to the point of being negligible allow the fear of AIDS to impair their sex lives and the development of relationships, it is hardly "presumptuous and preposterous" to suggest that their fears will have done them more harm than the disease itself, even though it is not possible to quantify the magnitude of the harm. Furthermore, there are large differences between mortality levels for single versus married people, as shown in Table 19 of my paper. It is unfortunate that Mr. Cowell chooses to use such words as "presumptuous" and "preposterous" in a professional journal, while producing no data to justify their usage.

Mr. Cowell ridicules my use of the word "only" in characterizing the 9,413 cases of AIDS attributed to heterosexual transmission in the 11 years from 1981 to 1991. However, during the same period there were nearly 200,000 AIDS cases attributed to other causes, and more than 20 *million* deaths from all causes in the U.S. I offer no apologies for contrasting these numbers by the use of the word "only." It is a proper use of the language, no less so because of Mr. Cowell's attempt to personalize the statistics.

Mr. Cowell quotes my statement that "we must recognize and publicize that AIDS *never* is going to become widespread throughout the general population, so long as reasonable health standards are followed." He then appears to criticize it by stating that "a reading of Mr. Plumley's paper and this discussion should attest to the point that people will have different interpretations of what constitutes 'reasonable' health standards." He follows this statement with a comment about the growing epidemic of other STDs in the U.S.

Yet one point I emphasize in my paper is the importance of prompt treatment of these diseases, particularly in the black community, where most of

the increase in STDs has occurred, to prevent AIDS from affecting the black community in the U.S. to the extent it already has in Africa. In fact, perhaps the most important single point that I make in the paper is that the best way to reduce the risk of HIV infection is to keep one's own body healthy, particularly in the genital area, and avoid sexual contact with those that are unhealthy (especially IV drug users).

In conclusion, my paper represents a serious effort to combine available data with actuarial techniques to place the risk of heterosexually transmitted AIDS in perspective, and to offer recommendations for AIDS education and prevention for heterosexuals that might prove to be more effective than those currently in place. I thank those who have contributed constructive comments and criticism, and urge those who may have misunderstood some of the points in the paper to reexamine it in the light of my author's reply.

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