A COST-BENEFIT ANALYSIS OF HIV-ANTIBODY TESTING FOR HOSPITAL PATIENTS

by

Sumner J. La Croix and Gerard Russo*

Working Paper No. 92-6
October 22, 1993

*Department of Economics, University of Hawaii, and Program on International Economics and Politics, East-West Center, (Dr. La Croix); and Department of Economics, University of Hawaii and Program on Population, East-West Center, (Dr. Russo), Honolulu, Hawaii.
ABSTRACT

Objectives: To develop a full taxonomy of potential benefits of HIV testing of hospital patients. To determine whether voluntary, routine testing of hospital patients for HIV is warranted under a cost-benefit criterion. To inform healthcare workers, hospital patients, and decision makers responsible for testing programs of the potential net benefits of routine testing.

Design: Benefits stemming from information about a patient’s HIV serostatus may accrue to (1) healthcare workers if extra precautions significantly reduce their HIV-exposure rate; (2) the patient if knowledge of HIV serostatus enables the patient to take prophylactic measures to extend life expectancy; and (3) the patient’s sex partners if the patient is less likely to transmit HIV after undergoing hospital HIV testing.

Methods: Using recent estimates on the value of life, hospital-specific HIV-prevalence rates, the effectiveness of prophylactic treatment, rates of HIV exposure and conversion by healthcare workers, and reduction in high-risk sexual behaviors by seropositive patients, we estimate the benefits of testing as the value of statistical life saved. The opportunity cost of testing is specified by the reported cost of an HIV-testing protocol and pre- and post-test counseling.

Results: Voluntary, routine HIV testing of hospital patients passes our cost-benefit test when benefits to the patient, to attending healthcare workers, and to the patient’s sex partners are jointly considered. Information about a patient’s HIV serostatus provides very small expected benefits to healthcare workers ($0.34) because risk of transmission is small; taken alone benefits to healthcare workers would not warrant routine HIV testing even in high HIV-prevalence hospitals. Information about a patient’s HIV serostatus provides relatively large expected benefits to the patient ($15,671) because of the availability of life extending treatment and to the
patient's sex partners ($4,918) because the risk of transmission can be reduced by adopting safer sex practices.

**Conclusion:** Routine, voluntary HIV testing programs in hospitals pass our cost-benefit test even in relatively low HIV-prevalence hospitals. Mandatory HIV testing in hospitals is, however, not recommended, as the potential exists for third-parties (employers, insurers, healthcare workers) to use the test to impose costs on HIV-seropositive patients. Since most benefits derived from information on the patient's HIV serostatus are realized by the HIV-seropositive patient obtaining prophylactic treatment and by the patient eliminating or reducing high-risk sexual behaviors, HIV-testing programs should be formulated to emphasize careful, effective, pre-and post-test patient counseling concerning the existence of potential benefits and reasonable plans for realizing them.
Introduction

Ever since the CDC reported the first episodes of occupational exposure to HIV in 1987\(^1\), there have been calls from some healthcare workers and politicians for mandatory HIV testing of all hospital patients. Advocates of hospital HIV testing argue that healthcare workers can use their knowledge of the patient’s HIV serostatus to take extra precautions against being infected with HIV; that patients who learn they are HIV seropositive can then undergo prophylactic treatment to extend their life expectancy; that patients who know their HIV serostatus are less likely to contract or spread the virus; and that general screening of patient blood helps to prevent the spread of other viruses, particularly the many types of hepatitis. Opponents of inpatient HIV testing argue that the costs of testing patients for HIV far outweigh the benefits accruing to healthcare workers; that healthcare workers may tend to take too few precautions with individuals who test HIV seronegative; and that patients testing HIV seropositive may experience discrimination in receiving healthcare, in obtaining health or life insurance, and in the workplace.

In this article we examine whether the benefits from voluntary, routine HIV testing of a selected group of hospital inpatients are substantially greater than the costs. Economists have previously applied cost-benefit analysis to other HIV policy issues, such as the efficiency of HIV screening of the blood supply,\(^2\) HIV screening of immigrants to Canada,\(^3\) HIV testing of healthcare workers,\(^4\) mandatory premarital HIV testing,\(^5\), and the cost-effectiveness of universal precautions regulations\(^6\). They have applied cost-effectiveness analysis to HIV screening of hospital patients to reduce HIV transmission from patients to healthcare workers,\(^7,8\) to identify HIV-seropositive patients for early treatment,\(^9\) and to reduce HIV transmission from patients to
their sex partners.\textsuperscript{10}

Our approach is unique in that it recognizes that the information from an HIV-antibody test is a "public good," i.e., that the use of the information from the HIV test by one person does not preclude others from also using the same information. We measure the potential benefits of HIV testing of hospital patients (1) to the patient; (2) to the patient's sex partners; and (3) to healthcare workers (HCWs) to whom the patient could transmit HIV. Since our analytical framework is structured to incorporate benefits to all three parties, it is able to provide a more accurate evaluation of the merits of inpatient HIV testing. We find that even in low HIV-prevalence hospitals, voluntary HIV testing of some patients in US hospitals passes a cost-benefit test using benchmark parameters. Our results apply only to a voluntary, routine HIV-testing program and can not be generalized to a mandatory HIV-testing program due to the potential for third parties to use the results of the HIV test to impose additional costs on inpatients via discrimination in employment, insurance, and access to healthcare.

\textit{Methods}

Hospital provision of voluntary, routine HIV testing is warranted if the benefits from testing exceed the costs. Benefits from testing some hospital patients for HIV may accrue to three parties: (1) the patient to whom the testing is offered; (2) the HCWs who may be exposed; and (3) the individual's sex partners.

If a patient is unaware of his HIV serostatus, the patient will not be undertaking prophylactic treatment to prevent opportunistic infections. If the patient consents to an hospital HIV test and learns that he is HIV seropositive, then prophylactic medical treatment can commence at an earlier stage of the illness than would otherwise have occurred. Such early
treatment may delay the onset of AIDS diagnosis, reduce the frequency of opportunistic infections, and extend the patient’s life expectancy. Two recent studies\(^9,\)\(^{11}\) estimate that prophylactic treatment after diagnosis of HIV infection leads on average to an additional 2.3-2.7 years of life.

Potential benefits from testing patients for HIV exist when HCWs generally take too few precautions against HIV. A patient’s seropositive HIV test may provide useful information if the HCW can then take extra precautionary measures being exposed to the HIV-seropositive patient’s blood. Extra precautions decrease the probability that the HCW will lose future years of their life due to HIV infection.

Benefits from HIV testing may also accrue to the patient’s sex partners. Some studies have shown that the HIV-seropositive patient is less likely to engage in high-risk sexual behaviors after learning his HIV status.\(^{10,\)\(^12\) In this case benefits accrue to the patient’s sex partners, as they are less likely to become HIV seropositive and to lose future years of life.

An HIV-antibody test differs from most medical procedures in that it is a "public good" rather a "private good." The consumption of a private good by one person precludes others from consuming the good. A hot dog is a good example of a private good. In contrast, the consumption of a public good by one person does not preclude others from also consuming the good.\(^{13,\)\(^14\) A television newscast is a good example of a public good. In general, information is a public good, as one person’s use of information does not "use up" the information.\(^15\) For example, one doctor’s use of a new technique for cardiovascular surgery (a public good) does not prevent another doctor from also using the same technique, whereas one patient’s use of an aspirin tablet (a private good) does preclude another patient from using that aspirin tablet. An
HIV-antibody test result is clearly a public good because the use of the test result by one person does not preclude the use of the test result by a second or third person. Thus the benefits from HIV testing to the patient, to HCWs, and the patient’s sex partners should all be considered in a cost-benefit analysis of HIV testing of hospital inpatients.

**Calculating HIV-Test Costs**

The opportunity cost of an HIV test is the value of the highest valued opportunity foregone. Since the testing process involves several components, the opportunity cost of testing a single hospital patient for HIV consists of the opportunity cost associated with each component. The standard HIV testing protocol is designed to reduce the percentages of false-positive and false-negative test results; it involves 3 steps. If the ELISA test is negative, report this result. If it is positive, conduct a second ELISA test and report a negative result. If the second ELISA test is positive, conduct a Western Blot (WB) test and report the WB result.

The HIV testing protocol does not, however, fully describe the test. Blood must be drawn, transported to a laboratory, and tested. The results must be interpreted, coded, and reported to the physician, and the patient notified and counseled. Thus, the cost of an HIV test includes (1) the cost of the test kit and materials used to draw the blood sample, (2) the rental cost of the laboratory in which the test is evaluated, and the time costs of the HCWs (3) who conduct the test in the laboratory, (4) who code and report the results, (5) who draw the blood, (6) who bring or send the blood sample to the analysis laboratory, (7) who inform and counsel the patient, and (8) who update patient records in the physician or hospital office.

The magnitude of the per patient cost of an HIV test to a hospital depends on two elements: (1) the number of HIV tests performed in a given period and (2) whether blood would
have been drawn from the patient if an HIV test had not been performed. As the number of HIV tests performed in the hospital increases, the marginal cost of a test decreases due to quantity discounts on test kits and lower processing costs stemming from increased specialization by hospital laboratory technicians. For hospital-based screening where blood samples are drawn on a routine basis, the marginal cost of an HIV test falls substantially, as the opportunity cost of the test does not include the cost of drawing the blood sample or transporting it to the lab.

Calculating Benefits From a Patient’s HIV Test to Healthcare Workers

The benefit to HCWs from testing hospital patients for HIV and taking additional precautions is the expected value of HCW life saved per patient surgery. This requires that we know the value of a HCW’s life and the number of lives per patient surgery saved by taking extra precautionary measures with HIV-seropositive patients.

First, let us determine how many HCW lives are lost per patient surgery if additional precautions are not undertaken. Since HIV transmission to HCWs can result from either parenteral exposure or cutaneous exposure to patient blood, our calculations take both transmission routes into account. If we define PREV as the percentage of hospital inpatients who are infected with HIV and do not provide this information to HCWs or present with symptomatic HIV disease; VL as the value of a HCW’s life foregone due to HIV infection and early death; CE_{ct} as the probability that a HCW has cutaneous exposure to a patient’s blood when the patient’s status is unknown and PE_{pt} as the probability of parenteral exposure; and PI and CI as the respective probabilities that parenteral and cutaneous exposure to a patient’s blood results in a HCW being infected with HIV, then the expected value of the HCW life lost per patient surgery can be expressed as (PREV x VL x CE_{ct} x CI) + (PREV x VL x PE_{pt} x PI).
If the hospital patient tests HIV seropositive, the HCW could take additional precautionary measures against HIV exposure, thereby possibly reducing the probability of cutaneous exposure from $CE_{at}$ to $CE_{at}$ and the probability of parenteral exposure from $PE_{at}$ to $PE_{at}$. Benefits to HCWs from HIV testing can be specified as $(PREV \times VL \times CI \times (CE_{at}-CE_{at})) + (PREV \times VL \times PI \times (PE_{at}-PE_{at}))$. In the next section we specify each of the parameters required to implement these benefit calculations.

**Parameter Values for Benefit Calculations**

**Value of Life (VL)**

To translate the number of lives saved into the value of lives saved is vital for any policy analysis which compares the costs and benefits flowing from a public policy. Economists have recently devised a methodology to infer this value from individual choices. It examines the premium that individuals must be paid to take on an activity with high risk of death or injury. Many economists used data on wage premiums and the probability of death on-the-job to calculate the implicit value that workers in dangerous jobs place on their lives.\(^{17-23}\) Other studies examined how much consumers are willing to pay to reduce the probability of accidental death. For example, Smith and Gilbert estimated the value of life by examining the premium a family is willing to pay for housing in a city with low air pollution and low risk of developing cancer.\(^{24}\)

Miller's survey of this literature finds that the mean and median value of life is $2.2 million with a standard deviation of $.65 million.\(^{20}\) For our purposes, we adopt estimates from Moore and Viscusi's 1988 and 1990 state-of-the-art studies.\(^{21-23}\) Their 1990 study identified a lower bound of $2.4 million and an upper bound of $6.4 million (in 1989 prices); we adopt the average value of the two bounds, $4.4 million, as our benchmark value of life.\(^{23}\)
The total value of life is, however, an overestimate of the value of life lost due to HIV infection, as HCWs do not die immediately after becoming infected with HIV. Using data from the San Francisco Men’s Health Study, Longini et al. estimate that the AIDS incubation period is $13.0 \pm 0.8$ years for a person who receives zidovudine and pentamidine (or trimethoprim-sulfamethoxazole) therapy when their T4-cell count drops below 500. Hellinger estimates that persons diagnosed with AIDS in 1993 will have a mean survival time of 2.08 years after diagnosis. Combining the Hellinger and Longini estimates, we conclude that the mean time between HIV infection and death is $15.08 \pm 0.8$ years. We adjust our value of life estimates to reflect this $15.08$-year average survival period. Using Viscusi and Moore’s estimate of the value of life ($4.4$ million) for a 38 year-old and Viscusi and Moore’s estimate of their sample population’s discount rate (12.2%), we calculate, using an annuity formula, that the present value of the $15.08$ years of life remaining to a 38-year-old newly infected with HIV is $3,730,000$. Subtracting this value from the full value of life ($4.4$ million) yields a benchmark value of life foregone due to HIV infection of $670,000$. Repeating these calculations for the upper bound ($6.4$ million) and lower bound ($2.4$ million) estimates of the full value of life, we obtain an upper bound estimate of $975,000$, and a lower bound estimate of $365,000$.

These revised value-of-life estimates are only rough estimates and should be considered in light of the following factors. First, new viral treatments for HIV and new treatments for opportunistic infections may extend the survival period for an HIV-seropositive person diagnosed in 1993 beyond 15.08 years, thereby reducing the value of life foregone due to HIV. Second, during the survival period, an HIV-seropositive person will sometimes be too ill to enjoy life as much as a healthy person, thereby increasing the value of life foregone due to HIV. Finally,
our value of life estimates are derived from workers who had an after-tax hourly wage of $11.96 (1989 dollars). HCWs with higher incomes (physicians) may assign higher values to their lives, thereby, increasing the value of life foregone due to HIV infection. HCWs with lower incomes (hospital attendants) may assign lower values to their lives, thereby, decreasing the value of life foregone due to HIV infection.

HIV Prevalence Rate in Hospitals (PREV)

Several recent studies present reliable information on the percentage of urban hospital patients infected with HIV\textsuperscript{28-28}. Janssen et al\textsuperscript{28} show that between September 1989 and October 1991, 9,286 blood specimens from 195,829 patients at 20 sentinel hospitals in 15 US cities tested seropositive for HIV-1. HIV seroprevalence ranges from .2% in hospitals in Salt Lake City, Utah and Omaha, Nebraska to 14.2% in a New York City hospital; the sample median is 2.45%. However, 32.4% of the seropositive individuals presented with symptomatic HIV infection or AIDS at admission. Since HCWs can already take additional precautions with patients who present with symptomatic HIV disease, we concentrate on HIV-seropositive patients who present with recognizable HIV disease.

Hospital-specific HIV seroprevalence rates vary considerably by age, sex, and race. Following Janssen et al\textsuperscript{28} we focus only on individuals aged 15 to 54, as this group captures 82% of the HIV-seropositive hospital patients who do not present with symptomatic HIV disease or AIDS. In Janssen et al\textsuperscript{28}'s sample, "[a]mong patients 15 to 54 years old who had presenting conditions other than symptomatic HIV infection or AIDS, the seroprevalence rate ranged from 0.7 percent to 23.6 percent in men, and from 0.1 percent to 12.4 percent in women, with an average overall rate of 5.05%."
Janssen et al\textsupERS{28} have estimated that the hospital-specific AIDS-diagnosis rate is closely related to the annual HIV-prevalence rate in that hospital. Their projections, summarized in Table 1, predict widely varying HIV-prevalence rates in US hospitals. We adopt an HIV-seropositive rate of 3.67\% (for the 593 US hospitals with an AIDS diagnosis rate which is $\geq 1.0$) as our benchmark estimate, 10.63\% (for the 77 US hospitals with an AIDS-diagnosis rate $\geq 5.0$) as our high estimate, and .31\% (for the 4,965 US hospitals with an AIDS diagnosis rate $< 1.0$) as our low estimate. We recognize, however, that 25 US hospitals are "outliers," with AIDS-diagnosis rates $\geq 9.0$ and implied HIV-seropositivity rates of 19.19\%.

\textit{Probability of Exposure to Blood (CE & PE)}

It is important to distinguish between cutaneous exposures which have a very low probability of producing an HIV infection and parenteral exposures which have a higher probability of producing an HIV infection. The best data on exposure rates come from a study by Gerberding et al\textsupERS{29} at San Francisco General Hospital. They studied 1307 consecutive surgical procedures during 1989 and identified 22 parenteral exposures in 22 cases (for an exposure rate of 1.68\%) and 95 cutaneous exposures in 62 cases (for an exposure rate of 7.27\%). Parenteral exposure rates differed significantly across surgical subspecialties. The parenteral exposure rate per surgery is higher for plastic (2.42\%), ob/gyn (1.74\%), and orthopedic (3.43\%) surgeons than for general (.94\%), ear/nose/throat (.48\%), and neurologic (0\%) surgeons.

\textit{Rate of Infection Upon Exposure (PI and CI)}

For parenteral exposures, Henderson et al\textsupERS{30} have estimated an infection rate of .29\% per exposure, with the 95\% confidence interval ranging from .13\% to .70\%. For cutaneous exposures, they identified no infections resulting from 2712 cutaneous exposures to blood from
HIV-1 infected patients. Four cases of HIV-1 seroconversion from cutaneous exposure to nonintact skin have, however, been reasonably substantiated for the United States. Fahey et al calculated, assuming a binomial distribution, that the upper bound of the 95% confidence interval is .04%, while the lower bound is 0.00%. Following Fahey, we adopt a theoretical risk from cutaneous exposures of .02%.

Results

Estimated HIV-Test Costs

There is a wide range of estimates of the cost of an HIV test which follows the protocols described earlier. Table 2 shows the estimates of the average costs of HIV testing reported in the literature. Costs estimates range from $3-4 reported by Eisenstaedt and Getzen and Burke et al for testing alone on a mass scale to $115 reported by McCarthy et al for repeated testing and counseling of seropositive patients in a physician office setting. We follow what can be considered representative literature and adopt the $35 estimate used by Turnock and Kelly, Petersen et al, and McKay and Phillips as our benchmark estimate of the average cost of testing and counseling. In recognition that costs in a hospital setting may be lower due to economies of scale and economies and scope in sero-testing and patient processing or higher due to the use of specialty medical personnel in counseling, we adopt Henry and Campbell’s $20 estimate for our low cost scenario, and McCarthy et al’s $67 estimate as our high cost scenario. Our main conclusions, however, do not critically depend on our costs assumptions.

Estimated HIV-Test Benefits to Healthcare Workers

To calculate the expected value of HCW life lost per patient surgery, we adopt median estimates for six parameters: rate of parenteral exposure = 1.68%; rate of cutaneous
exposure$^{29} = 7.28\%$; rate of infection per parenteral exposure$^{30} = .29\%$; rate of infection per cutaneous exposure$^{31} = .02\%$; the HIV-prevalence rate in hospitals with an AIDS diagnosis rate$^{28} \geq 1.0 = 3.67\%$; and the value of a statistical life foregone due to HIV infection ($\$670,000$). Using these benchmark parameters we obtain an expected loss of HCW life from parenteral exposure per patient surgery of $\$1.20 (0.0168 \times 0.0029 \times \$670,000 \times 0.0367)$ and from cutaneous exposure per patient of $\$3.36 (0.0727 \times 0.0002 \times \$670,000 \times 0.0367)$. The total value of HCW life lost per hospital patient surgery ($\$1.56$) varies significantly if we use upper or lower bound parameter estimates in lieu of our benchmark estimates. Using the lower bounds of all parameters, the expected value of HCW life lost per surgery is $\$0.03 (0.0168 \times 0.00135 \times \$365,000 \times 0.0031)$. Using the upper bound values of national specifications of all parameters, the expected value of HCW life lost is $\$12.19$ from parenteral exposures (0.0168 \times 0.007 \times \$975,000 \times 0.1063) and $\$3.01$ from cutaneous exposures (0.0727 \times 0.0004 \times \$975,000 \times 0.1063) or a total value of $\$15.20$.

An important sensitivity analysis is to examine how the expected loss of HCW life varies as we adopt change the hospital-specific HIV-prevalence rate, while continuing to use benchmark values for other parameters. We estimate the expected value of HCW life lost per patient surgery using hospital-specific AIDS diagnosis rates $< 1.0$ (HIV-prevalence rate = .31\%), $\geq 1.0$ (HIV-prevalence rate = 3.67\%), and $\geq 5.0$ (HIV-prevalence rate = 10.63\%). The expected value of HCW life lost per patient surgery is $\$1.13$ when the AIDS-diagnosis rate is $< 1.0$, $\$1.56$ when the AIDS-diagnosis rate is $\geq 1.0$, and $\$4.52$ when the AIDS-diagnosis rate is $\geq 5.0$. Table 3 summarizes our results.

The expected benefit from HIV testing is the reduction in the value of statistical life lost
once HCWs attending the patient become aware of the patient’s HIV-seropositive status. Gerberding investigated whether knowledge of a patient’s HIV status affected operating room personnel’s exposures to HIV\textsuperscript{37}. All operating personnel were already following OSHA’s universal precautions regulations. Gerberding et al found no difference in exposure rates between cases in which staff knew that the patient had tested HIV seropositive and cases in which staff knew that the patient had tested HIV seronegative. Gerberding’s study suggests that the HIV test yields no valuable information to HCWs if HCWS are already following universal precautions.

Do additional precautions beyond the mandated universal precautions significantly reduce the exposure rate? Gerberding’s study indicates no significant differences in exposure rates when surgical staff learned a patient’s HIV serostatus. Studies of the adoption of universal precautions have, however, documented significant reductions in exposure rates. Doebbeling et al\textsuperscript{38} found that adoption of universal precautions by an Iowa teaching hospital increased annual costs for isolation materials per hospital admission by $9.19 (1987 dollars). Fahey et al\textsuperscript{31} reported that the mean annual number of cutaneous exposures falls from 35.8 to 18.1 after universal precautions training, a decline of 51%. Wong et al\textsuperscript{39} report that needlestick injuries fell from .39 to .15 per patient care month, a decline of 62%.

Suppose we assume that additional expenditures on precautionary measures could theoretically be as effective in reducing the exposure rate as the initial expenditures on universal precautions. Following Wong and Fahey, we assume that a 62% reduction in parenteral exposures and a 51% reduction in cutaneous exposures is possible. Using our estimate of the value of life lost in high HIV-prevalence hospitals ($4.52), the value of HCW life saved from
taking extra precautions amounts to $2.63. The cost of realizing these savings (given the HIV-seropositive result is $9.19 \times 0.1063) spent on additional precautions for HIV seropositive patients. Thus the extra precautions generate net benefits of $1.65 per patient surgery. We have, however, surely overestimated the effectiveness of additional precautions by assuming that they are as effective as initial universal precautions. It is much easier to reduce exposure rates when they are at high levels than when they have already been reduced to low levels by the adoption of OSHA’s universal precautions. If more realistic measures of the effectiveness of precautions beyond universal precautions were adopted, net benefits would be reduced to lower positive or even negative levels.

Benefits to a Patient’s Sex Partners From Hospital HIV Testing

Recent analysis\(^{10}\) of voluntary, free HIV testing programs funded by the US Centers for Disease Control and Prevention (CDC) has shown that individuals who test HIV seropositive significantly reduce high-risk sexual behaviors. If a hospital inpatient who learns that she is HIV seropositive has the same behavioral response to the news as individuals who participated in the CDC program, then it becomes less likely that she will infect her sex partners. A cost-benefit analysis of voluntary, routine HIV testing in the hospital setting should incorporate the benefits derived by inpatients’ sex partners as well as benefits derived by the patient and HCWs.

Holtgrave et al\(^{10}\) conduct a well-specified cost-benefit analysis of the CDC-funded HIV counseling and testing (CT) program and conclude that the HIV-CT program clearly provides net benefits to society under a wide range of parameter specifications. Our analysis modifies the procedures specified by Holtgrave et al\(^{10}\) to allow the cost-benefit analysis to be conducted on a per-patient basis. For consistency with the remainder of our analysis, we also replace the
human capital measure of the value of life with the willingness-to-pay measure that we have used throughout this paper. It is worth noting, however, that the human capital measure of the value of life specified by Holtgrave et al\textsuperscript{10} ($433,000) is between our benchmark value of life ($670,000) and our low value ($365,000).

Following Holtgrave et al\textsuperscript{10} we specify two scenarios: a base-case scenario and an "increased risk of infection due to learning HIV seronegative" scenario. The base-case scenario assumes that individuals who learn they are HIV seronegative do not change their sexual behaviors, while some individuals who learn they are HIV seropositive reduce or eliminate high-risk sexual behaviors and thereby prevent the transmission of HIV to their sex partner. Accurate point estimates for the percentage of HIV-seropositive individuals who change their behavior (E) are unavailable, so we follow Holtgrave et al in using (1) two estimates for E (0.2 and 0.5); (2) assuming that each patient has one sex partner; and (3) that the patient has not already transmitted HIV to the sex partner. The benefit (B) derived per patient screened for HIV is $B = P\text{REV} \times V\text{L} \times E$. The "increased risk of infection due to learning HIV seronegative" scenario incorporates the same behavioral changes by HIV-seropositive individuals as the base case, but also incorporates an increase in high-risk sexual behaviors by individuals who learn they are HIV seronegative. Higgins et al\textsuperscript{12} survey the literature studying the impact of HIV-negative serostatus on sexual behaviors and conclude that the evidence is mixed. Some studies\textsuperscript{41-44} have found no change in individual behavior after their HIV-seronegative status is learned, while others\textsuperscript{40} find some increase in risky behavior. We follow Holtgrave et al\textsuperscript{10} in assuming that the increased risk (IR) taking by these HIV-seronegative inpatients will result in an additional one percent of this population becoming HIV seropositive. The benefit (B) derived
per patient screened for HIV is $B = (\text{PREV} \times \text{VL} \times E) - ((1-\text{PREV}) \times \text{IR} \times \text{VL})$.

We report results for both scenarios in Table 4. The results are very sensitive to assumptions concerning (1) the hospital-specific HIV-prevalence rate; (2) the efficacy (E) of counseling provided to HIV-seropositive patients; and (3) the behavioral response of HIV-seronegative patients. However, in high HIV-prevalence hospitals, HIV testing generates extremely large benefits regardless of which scenario or which efficacy assumptions we adopt; benefits in high HIV-prevalence hospitals range from $8,259 to $89,025 per patient. In high HIV-prevalence hospitals (10.63% of patients are HIV seropositive), patient HIV testing generates large benefits because the positive benefits generated by the large percentage (PREV x E) of seropositive individuals who reduce or eliminate high-risk sexual behaviors after they learn their HIV status overwhelm the negative benefits generated by the smaller percentage ((1-PREV) x IR) of seronegative individuals who increase their high risk sexual behavior after learning their HIV serostatus. In high HIV-prevalence hospitals, HIV testing is warranted on the basis of this analysis alone.

HIV-testing benefits range from -$6,264 to $14,244 in low and benchmark HIV-prevalence hospitals. In hospitals with an HIV-prevalence rate less than or equal to our benchmark rate (3.67%), it is important to specify the behavioral responses of HIV-seronegative individuals more accurately before recommending testing or the net effect of HIV testing may be increased transmission of HIV.

*Patient Benefits From HIV Testing*

While controversy continues concerning the benefits of antiviral treatment during the early stages of HIV disease, several studies have established that prophylactic treatment for an
HIV-seropositive individual with fewer than 500 CD4-positive cells per cubic millimeter increases the individual’s life expectancy.\cite{45,48} McCarthy et al\cite{9} conduct a well-specified cost-effectiveness analysis of screening populations for HIV so that identified HIV-seropositive individuals can obtain prophylactic treatment to increase life expectancy. They conclude that "[i]n populations with a prevalence as low as 0.15\%, screening costs only $29,000 per life-year gained\cite{9} and that screening should be routinely offered in populations where seroprevalence is 0.5\% or more. Our analysis modifies the procedures specified by McCarthy et al\cite{9} to allow the analysis to be conducted on a per-patient basis. In addition, consistent with the rest of our analysis, we specify an explicit value for each year of life gained. These modifications enable us to jointly consider benefits accruing to all parties (patient, HCWs, and patient’s sex partner) from an inpatient’s HIV test.

Our analysis uses two central results from McCarthy et al\cite{9}. First, they find that the additional cost of prophylactic treatment for an HIV-seropositive person who learns he is seropositive prior to AIDS diagnosis is $22,100. Their prophylactic treatment protocol includes a comprehensive medical evaluation after the positive test result, aerosolized pentamidine (300 mg per month) for patients with T4 counts less than 200 per cubic millimeter, zidovudine (500 mg per month) for patients with T4 cell counts less than 500 per cubic millimeter, and regular office visits and laboratory tests which vary in frequency with the T4 cell counts. See McCarthy et al\cite{9} for a more complete specification of the treatment protocol. Second, McCarthy et al\cite{9} find that the prophylactic treatment protocol produces an average gain in life expectancy of 2.3 years. This is roughly consistent with Longini et al’s\cite{11} conclusion that prophylactic treatment increases the estimated time to an AIDS diagnosis by 2.7 years. To ensure that we do not exaggerate the
gains to the patient from HIV testing, we adopt 2.3 years as our benchmark estimate of the number of years of life gained from prophylactic treatment prior to AIDS diagnosis.

To calculate per patient benefits from McCarthy et al.'s prophylactic protocol, we need to specify how long the patient has been HIV seropositive when the test is conducted. Without prophylactic treatment, the average time between HIV infection and AIDS diagnosis (the "AIDS incubation period") is 10.3 years. We assume that the average patient will be hospitalized midway through this period, at 5.15 years since HIV infection. Without prophylactic treatment prior to AIDS diagnosis, the patient would live 10.3 until AIDS diagnosis and survive an additional 2.08 years with AIDS, for a total of 12.38 years. With prophylactic treatment prior to AIDS diagnosis, the patient would live an additional 2.3 years until AIDS diagnosis (12.6 years total) and survive an additional 2.08 years with AIDS, for a total of 14.68 years. Thus a hospital patient who learns his serostatus 5.15 years after HIV infection and begins prophylactic treatment prior to AIDS diagnosis would live 9.53 years rather than 7.23 years.

Using our benchmark estimate of the value of life to a 38-year-old ($4.4 million) and a discount rate of 12.2 percent, we estimate that the benefit to the patient of living 9.53 years rather than 7.23 years amounts to $449,100. Adjusted for the treatment cost ($22,100), the net value per seropositive patient is $420,000. Since our analysis is in per patient units, we must also adjust for the probability that the patient is HIV seropositive. At our benchmark hospital-specific HIV-prevalence rate of 3.67%, the per patient benefit from an HIV test is $15,671. Table 5 summarizes results for a range of hospital-specific HIV-prevalence rates. Benefits remain robust when we vary other benchmark parameters. If we set all parameters at their low specifications (VL = 2.4 million, hospital-specific HIV-prevalence = .31%) and assume that
prophylactic treatment is effective in 50% fewer patients, we still obtain per patient benefits equal to $361. Voluntary, routine testing of hospital patients appears to be warranted on the basis of this analysis alone.

A Cumulative Cost-Benefit Analysis

Other analysts have evaluated benefits to HCWs, to patients, and to the patient’s sex partners from HIV testing. Our study synthesizes these analyses by specifying a unified framework in which all three types of benefits can be jointly considered. It is useful to consider all three benefits simultaneously, as the information from an HIV test is a public good: one person’s use of the knowledge that the patient is HIV seropositive does not preclude other persons from also using this knowledge. Since an individual’s HIV serostatus is a public good and several individuals can simultaneously reap benefits from the information, the potential benefits derived by all affected parties should be added together and compared with the cost of an HIV test. Table 6 calculates benefits at the specified benchmark parameters and examines their sensitivity to variation in HIV-prevalence rates. Benefit-cost ratios range from 50:1 to 1704:1, thereby indicating that voluntary, routine HIV testing is warranted given our benchmark parameters.

In Table 7 we examine whether the cost-benefit results from the benchmark model are robust to variation in parameters. First, we set all parameters at their low values and continue to assume that HIV-seronegative patients will not change their sexual behaviors after they learn they are seronegative. In this case (column 1), we find that while net benefits from testing fall substantially, they remain high in absolute terms ($948), yielding a benefit-cost ratio of 14:1.

The only exception to our conclusion about the efficacy of HIV testing occurs when
patients who learn they are HIV-seronegative decide to engage in more high-risk sexual behaviors. In low HIV-prevalence hospitals, the benefits to the HIV-seronegative patient from HIV testing are negative, and this effect dominates other positive benefits accruing to identified HIV-seropositive patients. At our benchmark HIV-prevalence hospital (PREV = 3.67%), the gains to HIV-seropositive patients outweigh the losses to HIV-seronegative patients, and testing generates positive overall benefits. It is, therefore, particularly important for researchers to refine preliminary findings on the behavioral responses of individuals who learn they are HIV seronegative.

Examination of Table 6 also reveals that HIV testing of hospital patients to prevent HIV transmission to HCWs fails a stand alone cost-benefit test. In high HIV-prevalence hospitals, the benefits from testing are only $1.65, far less than the $35.00 cost of the HIV testing protocol (which includes besides the lab tests, pre- and post-test counseling costs and record keeping costs). Since 99% of the benefits derived from inpatient HIV testing are derived from the HIV-seropositive patient receiving prophylactic treatment and from the HIV-seropositive patient reducing high-risk sexual behaviors, a voluntary, routine, hospital HIV-testing program should emphasize the provision of counseling to the patient so that these benefits can be reaped.

Comment

The CDC\textsuperscript{50} has recommended that hospitals with AIDS-diagnosis rates \(\geq 1.0\) provide a program of routine, voluntary HIV testing to hospital patients. "Routine" implies that the hospital counsels each inpatient about the benefits of taking an HIV-test as well as potential negative consequences and offers each patient the opportunity to take an HIV test. "Voluntary" implies that patients can refuse to take an HIV test and still obtain access to the hospital's
services. Our results clearly show that a policy of routine, voluntary HIV testing for hospital patients is warranted by cost-benefit analysis, even in low HIV-prevalence hospitals. If, however, patients who learn they are HIV-seronegative engage in more high-risk sexual behaviors, then the testing program may not only fail a cost-benefit test, i.e., positive benefits are less than positive costs, but also inflict harm on the patient, i.e., the test generates negative gross benefits. In a low HIV-prevalence hospital, the per patient gains from reduced HIV transmission to HCWs and from prophylactic treatment of HIV-seropositive patients is very low because the percentage of HIV-seropositive patients is very low. Since the percentage of HIV-seronegative patients is correspondingly very high, the negative benefits arising from increases in high-risk sexual behavior by HIV-seronegative patients can easily overwhelm the positive benefits accruing to HCWS and HIV-seropositive patients. While most studies show that individuals who learn they are seronegative do not engage in more high-risk sexual behaviors, it is important to clarify this question before routine HIV testing is implemented in low HIV-prevalence hospitals.

Like most cost-benefit studies, our analysis does not incorporate some potentially important factors. While our analysis above has stressed the public good dimensions of information, it is important to also realize that information can be a "public bad." Individuals may use information to impose costs on other individuals if, in so doing, they reap a positive gain. In some instances the costs imposed on other individuals will not outweigh the gains realized by the person using the information. Thompson and Borenstein have already shown that the use of the HIV test by health insurance companies to exclude applicants for health insurance may satisfy this criterion.
Let us examine some of the costs which may be associated with information about an individual’s HIV serostatus and our not incorporated in our calculations. First, HCWs may pay too little attention to patients identified as HIV seropositive. A physician who wants to avoid exposure to HIV may refer a large percentage of HIV-infected patients to other physicians, leading to reduced access to medical care for HIV-infected persons. Second, information about the HIV test result may be indirectly communicated to the patient’s health insurer or employer. Both have financial incentives in some situations to exclude the individual from future employment or insurance. Finally, knowledge of HIV test results may induce HCWs to reduce the level of precautions they take with patients who test seronegative. This is potentially important because precautionary measures not only protect HCWs against HIV, but also against the many forms of hepatitis (A,B,C), HTLV-1, cytomegalovirus, and other blood-borne pathogens.

Mandatory HIV-testing is flawed because it provides no protection against the negative consequences accruing to the HIV-seropositive patient from HIV testing. The potential benefits to HCWs, the patient’s sex partner, and the patient are sufficiently large to warrant routine, voluntary HIV testing despite the potential for some discrimination. For a program of routine, voluntary HIV testing to succeed, individuals should be informed of the potential for these negative consequences to occur. The individual should be provided with information on legal protections against discrimination in employment, insurance, and health care, and urged to evaluate the potential for discrimination given their particular situation. Some states prohibit discrimination in employment and medical care based on HIV serostatus, while others provide relatively weak protections. Individuals should be aware of the existence of or lack of legal
protections against discrimination. If the patient and hospital staff evaluate the potential for discrimination based on serostatus to be low, then our results indicate that the substantial benefits derived by the patient and the patient's sex partners as well as the small benefits derived by HCWs warrant a policy of routine, voluntary HIV testing for hospital patients. We follow the CDC in recommending that all hospitals with AIDS-diagnosis rates \( \geq 1.0 \) (or equivalently, HIV-prevalence rates greater than 3.67%) adopt a program of routine, voluntary HIV testing.
Table 1. Estimates of HIV-Prevalence Rates in US Acute Care Hospitals

<table>
<thead>
<tr>
<th>Hospital-Specific AIDS-Diagnosis Rate</th>
<th>Number of Hospitals</th>
<th>Predicted HIV-Prevalence Rate Among 15-54-Year-Olds Tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1.0</td>
<td>4,965</td>
<td>.31%</td>
</tr>
<tr>
<td>≥1.0</td>
<td>593</td>
<td>3.67%</td>
</tr>
<tr>
<td>≥5.0</td>
<td>77</td>
<td>10.63%</td>
</tr>
<tr>
<td>≥10.0</td>
<td>25</td>
<td>19.19%</td>
</tr>
</tbody>
</table>

Source: Janssen et al\textsuperscript{28}. The HIV-prevalence rate is calculated for inpatients who present without evidence of symptomatic HIV disease.
Table 2. Estimates of the Average Cost of HIV Testing

<table>
<thead>
<tr>
<th>Study</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eisenstaedt and Getzen²</td>
<td>$3.20*</td>
</tr>
<tr>
<td>Burke, et al³²</td>
<td>$4.40†</td>
</tr>
<tr>
<td>Zowall, et al³</td>
<td>$17.50‡</td>
</tr>
<tr>
<td>Henry and Campbell³⁵</td>
<td>$10.00§</td>
</tr>
<tr>
<td>Henry and Campbell³⁵</td>
<td>$20.00¶</td>
</tr>
<tr>
<td>Cleary, et al³⁴</td>
<td>$31.00**</td>
</tr>
<tr>
<td>Turnock and Kelly³³</td>
<td>$35.00††</td>
</tr>
<tr>
<td>Petersen, et al³⁶</td>
<td>$35.00‡‡</td>
</tr>
<tr>
<td>McCarthy et al⁹</td>
<td>$67.00†††</td>
</tr>
<tr>
<td>McCarthy et al⁹</td>
<td>$115.00‡‡‡</td>
</tr>
</tbody>
</table>

* Includes initial ELISA test, and repeat ELISA test and Western blot test as indicated.
† Includes specimen transport, record keeping, ELISA test and Western blot test as indicated.
‡ Includes Elisa test(s) and confirmatory Western blot test as indicated (21 Canadian dollars converted to US dollars with an exchange rate of 1.2).
§ $10 laboratory costs only.
¶ $10 laboratory costs, other direct costs (i.e., administration, confirmatory Western blot testing, record keeping) and indirect costs (CDC project).
** Includes testing $6 and counseling $25.
†† Includes pretest and post-test counseling, and repeated ELISA tests and Western blot tests as indicated.
‡‡ Includes testing and counseling.
§§ Includes one ELISA test at $11, and two standard office visits at $28.
¶¶ Includes two ELISA tests at $11 each, one Western blot test at $24, one standard office visit at $28 and one intermediate office visit at $41.
Table 3. Value of HCW Life Lost Per Hospital Surgery Due to HIV Transmission

<table>
<thead>
<tr>
<th>Summary of Assumptions</th>
<th>Value of Life Lost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Benchmark values of all parameters.</td>
<td>$1.56</td>
</tr>
<tr>
<td>2. High estimates of all parameters.</td>
<td>15.20</td>
</tr>
<tr>
<td>3. Low estimates of all parameters.</td>
<td>.03</td>
</tr>
<tr>
<td>4. Benchmark parameters with high estimate of the hospital-specific HIV-prevalence rate</td>
<td>4.52</td>
</tr>
<tr>
<td>5. Benchmark parameters with low estimate of the hospital-specific HIV-prevalence rate</td>
<td>.13</td>
</tr>
</tbody>
</table>
Table 4. Value of Life Gained by the Patient’s Sex Partner

<table>
<thead>
<tr>
<th>Hospital-Specific HIV-Prevalence Rate</th>
<th>Efficacy (E)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.2</td>
<td>0.5</td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Case</td>
<td></td>
<td></td>
</tr>
<tr>
<td>.31%</td>
<td>$415</td>
<td>$1,039</td>
</tr>
<tr>
<td>3.67%</td>
<td>$4,918</td>
<td>$12,295</td>
</tr>
<tr>
<td>10.63%</td>
<td>$14,244</td>
<td>$89,025</td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased Risk Case</td>
<td></td>
<td></td>
</tr>
<tr>
<td>.31%</td>
<td>-$6,264</td>
<td>-$5,640</td>
</tr>
<tr>
<td>3.67%</td>
<td>-$1,536</td>
<td>$5,841</td>
</tr>
<tr>
<td>10.67%</td>
<td>$8,259</td>
<td>$83,040</td>
</tr>
</tbody>
</table>

Formulas are as follows. Base Case: $B \ (Benefit) = PREV \times E \times VL$. Increased risk of infection due to learning HIV- Case: $B = (\text{Base Case } B) - ((1 - PREV) \times IR \times VL)$. Value of life gained (VL) = $670,000; Increased risk due to learning HIV- (IR) = 1%. HIV-prevalence (PREV) = 3.67%.
Table 5. Net Value of Life Gained Per Inpatient by Early Treatment

<table>
<thead>
<tr>
<th>Hospital-Specific HIV-Prevalence Rate for 15-54-Year Olds</th>
<th>Additional Years of Life Gained</th>
<th>Additional Treatment Cost</th>
<th>Net Value Per Inpatient of Additional Years of Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>McCarthy et al(^9) Case</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.31%</td>
<td>2.3</td>
<td>$22,100</td>
<td>$1,324</td>
</tr>
<tr>
<td>3.67%</td>
<td>2.3</td>
<td>$22,100</td>
<td>$15,671</td>
</tr>
<tr>
<td>10.63%</td>
<td>2.3</td>
<td>$22,100</td>
<td>$45,390</td>
</tr>
<tr>
<td>19.19%</td>
<td>2.3</td>
<td>$22,100</td>
<td>$81,941</td>
</tr>
<tr>
<td>Longini et al(^11) Case</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.31%</td>
<td>2.7</td>
<td>$22,100</td>
<td>$1,516</td>
</tr>
<tr>
<td>3.67%</td>
<td>2.7</td>
<td>$22,100</td>
<td>$17,948</td>
</tr>
<tr>
<td>10.63%</td>
<td>2.7</td>
<td>$22,100</td>
<td>$51,984</td>
</tr>
<tr>
<td>19.19%</td>
<td>2.7</td>
<td>$22,100</td>
<td>$93,846</td>
</tr>
</tbody>
</table>

The analysis assumes that (1) the patient with HIV has an AIDS-incubation period of 10.3 years without treatment (Longini\(^11\)); (2) an AIDS-incubation period of either 12.6 years (McCarthy\(^9\)) or 13.0 years (Longini\(^11\)) with treatment; and the patient learns his HIV serostatus 5.15 years after the initial HIV infection. The net value (\(NV\)) of the additional years of life per hospital inpatient is determined by an annuity formula:

\[
NV = \left( TV \times \left( [1 - e^{-r t}] - [1 - e^{-r t_e}] \right) - TC \right) \times PREV
\]

where \(TV\) = total value, \(TC\) = treatment cost, and \(r\) is the discount rate, \(t_e\) is life expectancy 5.15 years after HIV infection without prophylactic treatment, \(t_i\) is life expectancy 5.15 years after HIV infection with prophylactic treatment, and \(PREV\) is the hospital-specific HIV-prevalence rate.
Table 6. Cumulative Benefits and Costs from Patient HIV Testing with Benchmark Parameters

<table>
<thead>
<tr>
<th>Hospital-Specific HIV-Prevalence Rate for 15-54-Year Olds</th>
<th>.31%</th>
<th>3.67%</th>
<th>10.63%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Benefits to healthcare workers per surgical patient</td>
<td>$0.05</td>
<td>$0.34</td>
<td>$1.65</td>
</tr>
<tr>
<td>2. Net benefits to patient from early detection</td>
<td>$1,324</td>
<td>$15,671</td>
<td>$45,390</td>
</tr>
<tr>
<td>3. Benefits to patient’s sex partner(s)</td>
<td>$415</td>
<td>$4,918</td>
<td>$14,244</td>
</tr>
<tr>
<td>4. Total net benefits (1+2+3)</td>
<td>$1,739</td>
<td>$20,589</td>
<td>$59,636</td>
</tr>
<tr>
<td>5. Cost of HIV test</td>
<td>$35</td>
<td>$35</td>
<td>$35</td>
</tr>
<tr>
<td>6. Net Benefits/Cost Ratio (4/5)</td>
<td>50:1</td>
<td>588:1</td>
<td>1,704:1</td>
</tr>
</tbody>
</table>
Table 7. Cumulative Benefits and Costs from Patient HIV Testing with Parameters Biased Against Accepting Cost-Benefit Analysis

<table>
<thead>
<tr>
<th>Hospital-Specific HIV-Prevalence Rate for 15-54-Year Olds</th>
<th>HIV-Seronegative Behavior Change</th>
<th>No HIV-Seronegative Behavior Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Benefits to healthcare workers per surgical patient</td>
<td>$0.03</td>
<td>$0.03</td>
</tr>
<tr>
<td>2. Net benefits to patient from early detection</td>
<td>$722</td>
<td>$722</td>
</tr>
<tr>
<td>3. Benefits to patient's sex partner(s)</td>
<td>-$6,264</td>
<td>$226</td>
</tr>
<tr>
<td>4. Total net benefits (1+2+3)</td>
<td>-$5,542</td>
<td>$948</td>
</tr>
<tr>
<td>5. Cost of HIV test</td>
<td>$67</td>
<td>$67</td>
</tr>
<tr>
<td>6. Net Benefits/Cost Ratio (4/5)</td>
<td>-83:1</td>
<td>14:1</td>
</tr>
</tbody>
</table>
REFERENCES


