

**HIV Rapid Testing:  
Challenges to Public Health**

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**Functions of HIV Testing**

- Screening blood for Transfusions
- Surveillance and monitoring
- Voluntary counseling and testing (VCT)
- Perinatal prevention programs

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**Traditional Diagnostic HIV Testing**

- Since inception, testing technology driven by blood screening needs:
  - High volume
  - Complex equipment
  - Technically demanding
  - Centralized, time-consuming

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**Newer Simple and/or Rapid Assays**

- Point-of-service testing
- Minimal equipment requirements
- Straightforward interpretation
- Immediate test results
- Cost \$0.45 - \$7.50 US

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### Public Health Need for Rapid HIV Tests

- High rates of non-return for test results
- Need for immediate information or referral for treatment choices
  - Perinatal settings
  - Post-exposure treatment settings
  - Preventive therapy for opportunistic infections
- Screening in high-volume, high-prevalence settings



### Behaviors after Learning HIV Diagnosis

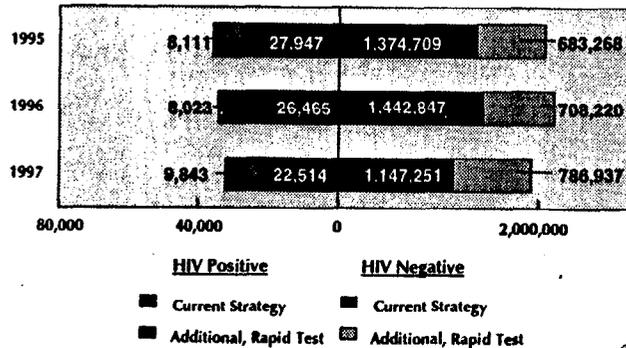
- Interviews with men who have sex with men and heterosexual men and women within 12 months after finding out they were HIV-positive indicated:
  - 60% used condoms more often
  - 49% had sex less often
  - 36% had not had any sex
  - 10% had sex only with other HIV-positive persons

MMWR, in press



### All CTS Sites

Receipt of HIV test results by testing strategy



### Predictive Value: Single Screening Test

Observed SUDS Specificity 99.6%

HIV Prevalence	Predictive Value Positive
10%	96%
5%	91%
2%	80%
3%	86%
1%	67%
0.5%	50%
0.3%	38%
0.1%	18%



### Perinatal Diagnosis with Screening Tests

	<u>New York</u>	<u>Charity Hospitals</u>
Newborns diagnosed only if rapid tests are used	24%	20%
HIV Prevalence	0.3%	3.1%
False positive with only a single screening test	40%	17%
Predictive value positive (predicted)	60% (50%)	83% (86%)



### Opportunities for HIV Screening in High Volume, High Prevalence Sites

	<u>HIV Prevalence</u>	<u>Reference</u>
Bronx-Lebanon Hospital, New York	5.4%	<i>Irwin et al. Ann Int Med 1996</i>
Johns Hopkins Emergency Department, Baltimore	6.4%	<i>Kelen et al. Ann Emerg Med, 1999</i>
Grady Hospital Urgent Care Clinic, Atlanta	2.3%	<i>Del Rio et al. Durban abstract, 2000</i>
Cook County Hospital CORE clinic, Chicago	2.3%	<i>Kendrick et al. Durban abstract, 2000</i>
U.S. publicly-funded HIV testing sites	1.1%	<i>CDC. HIV CT Summary Report, 1995</i>

### CDC Prevention Initiative:

### Serostatus Approach to Fighting the Epidemic (SAFE)



### SAFE for HIV-Infected Persons

- Action Step 1      Increase number of infected individuals who know their HIV status as early after infection as possible
- Action Step 2      Promote entry into health care and prevention services
- Action Step 3      Increase the number of HIV- infected persons who are receiving appropriate care and treatment services
- Action Step 4      Increase adherence to prescribed antiretroviral therapies
- Action Step 5      Support the adoption and maintenance of HIV risk reduction behavior



### SAFE for High-Risk HIV-Negative Persons

- Improve referral systems
- Provide more intensive science-based prevention services
- Strengthen the link between counseling, HIV testing, and other services



### Rapid HIV Testing Is Essential

- Treatment opportunities:
  - Offer prophylaxis to prevent vertical transmission
  - Identify HIV-infected persons who need treatment (antiretroviral; opportunistic infections)
  - Guide treatment decisions after occupational exposures
- Prevention:
  - Help eradicate vertical transmission
  - Help reduce sexual transmission



### The Need for Several Rapid Tests

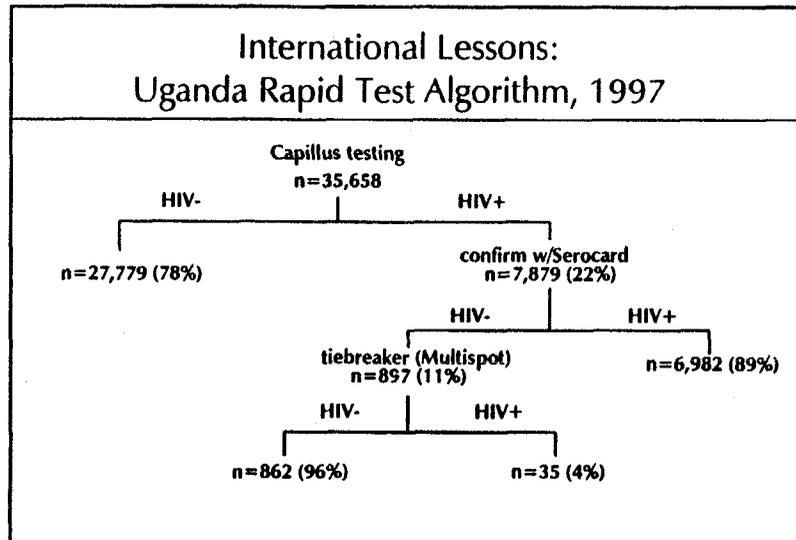
- Only one currently licensed RT is available in the U.S.
- Use of 2 different RTs would increase sensitivity, specificity and predictive value to ~100%, comparable to existing algorithm of EIA & confirmatory tests.



### Honduras: Predictive Value of Rapid Test Combinations

	Low Prevalence (1.5%) (n=857)		High Prevalence (30.5%) (n=402)	
	PPV	NPV	PPV	NPV
Retrocell + HIVChek	100	100	100	99.6
Retrocell + Multispot	100	100	100	99.6
HIVChek + Multispot	100	100	100	99.3



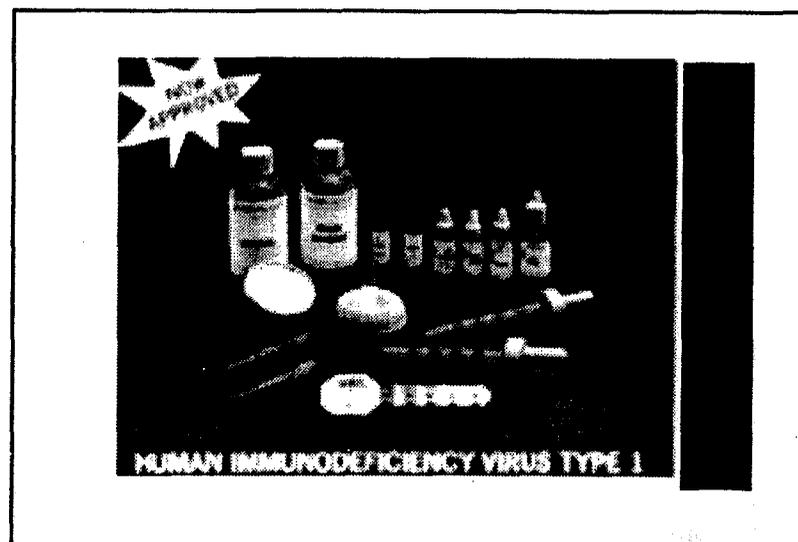


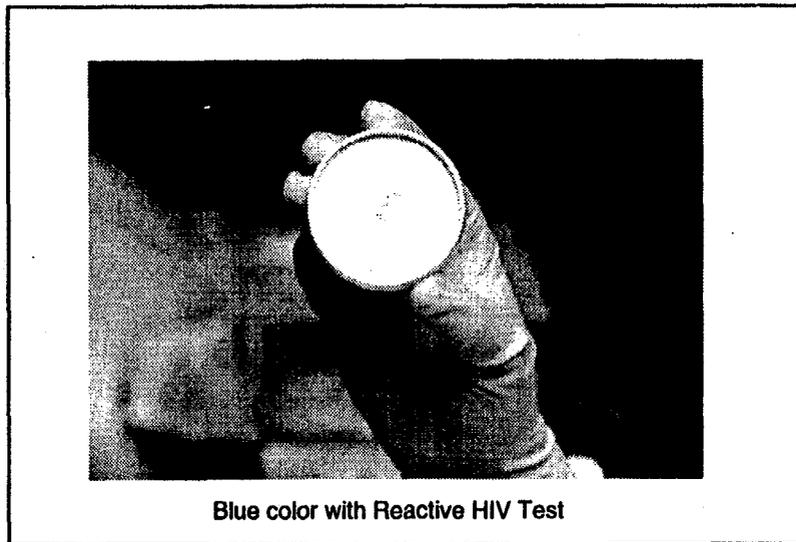
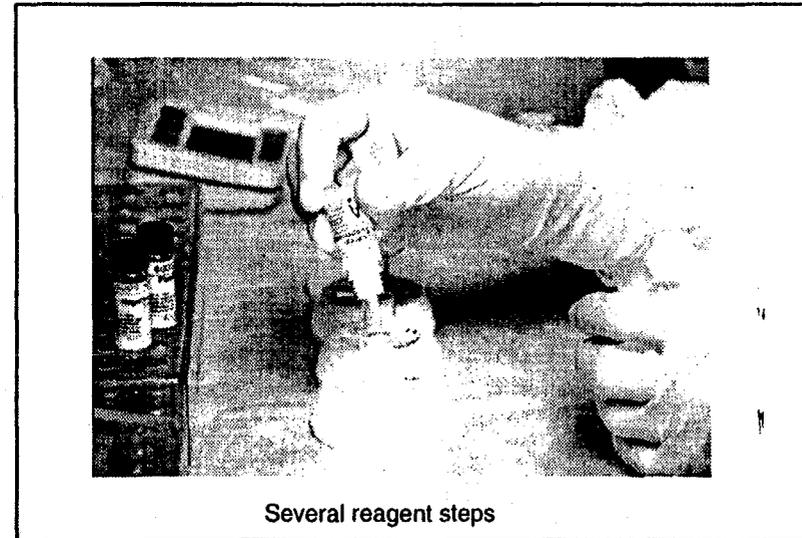
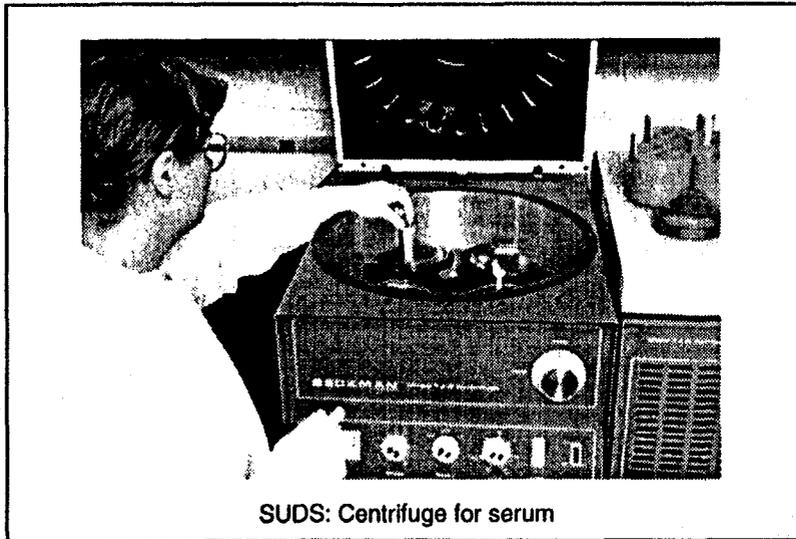
### CDC Efforts and the Availability of Rapid Tests

- Based on identified public health need:
  - Encourage manufacturers to commercialize rapid tests in the United States.
  - Conduct clinical trials to establish test performance in settings of intended use.
  - Provide data for PMA applications to speed FDA approval.
  - Evaluate use of specific combinations of rapid tests to increase predictive value.

### Trials Necessary for Prospective Tests

- Low and high prevalence settings
- Settings of intended use:
  - Perinatal
  - Corrections
  - Military
  - STD clinics, etc.
- Combination-test algorithms

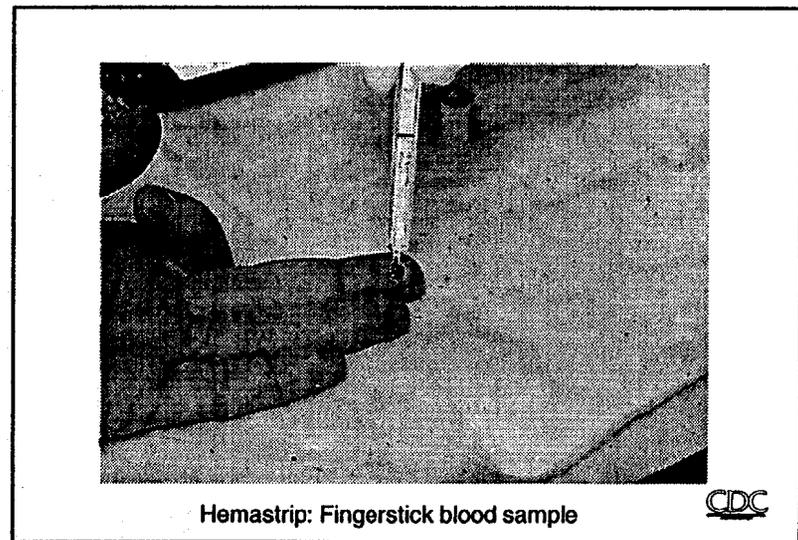
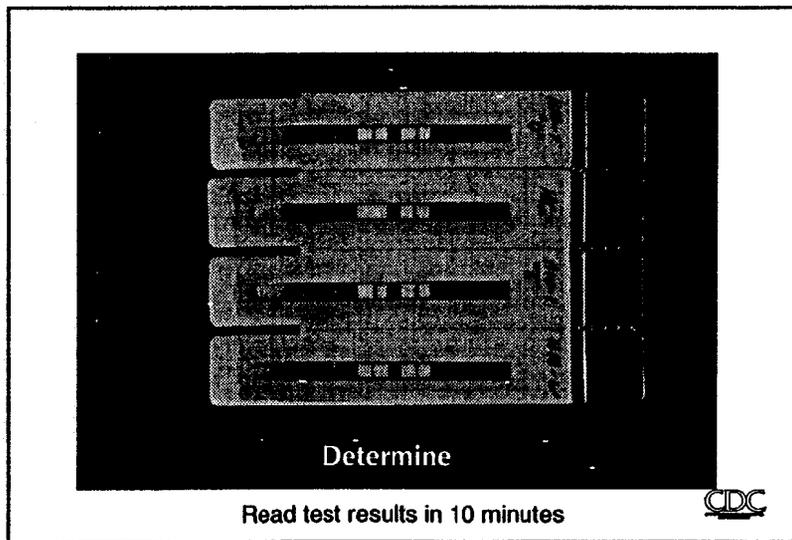
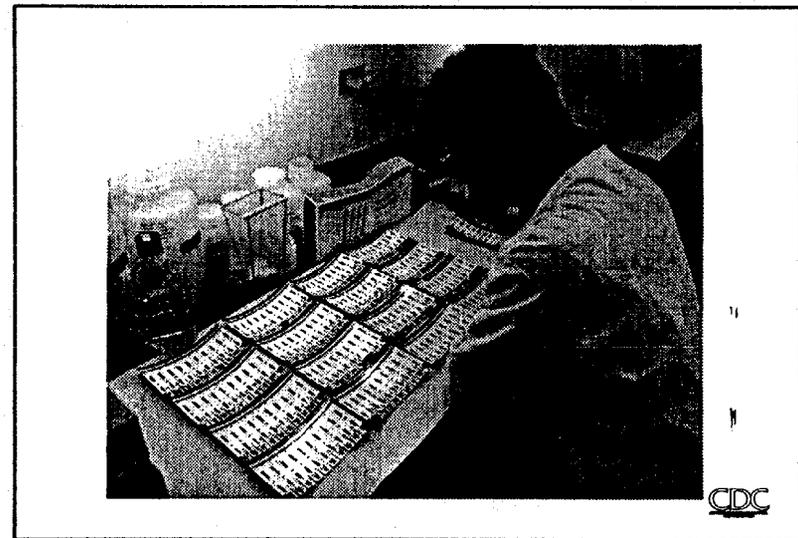
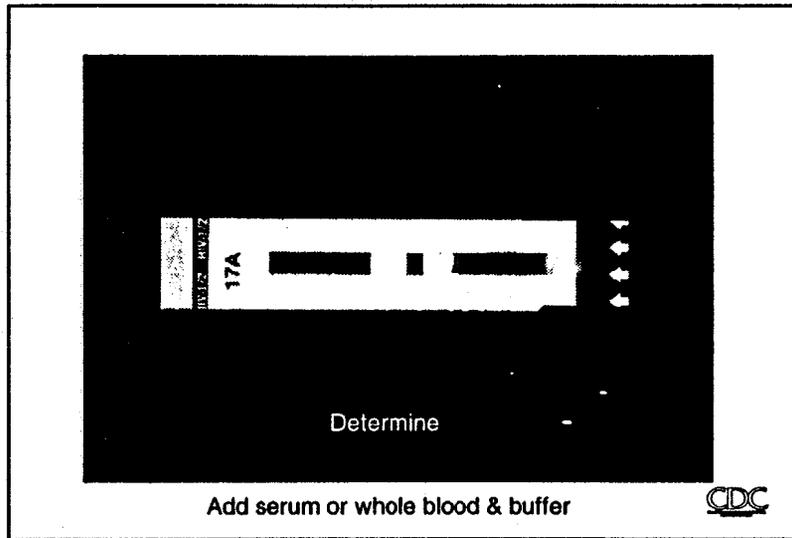


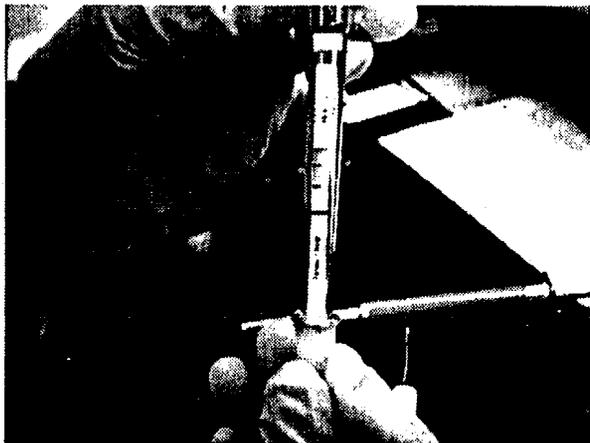


### Rapid Test Candidates

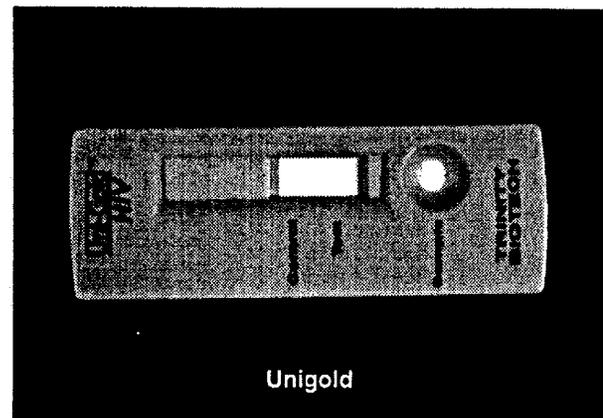
- Selection criteria for candidate rapid tests:
  - Availability of clinical performance data from manufacturer
  - User-friendly performance characteristics
    - Ease of use and interpretation of endpoints
    - Minimal technical requirements
    - Suitable for use in field settings, especially on whole blood or finger-stick specimens







Read results in 15 minutes

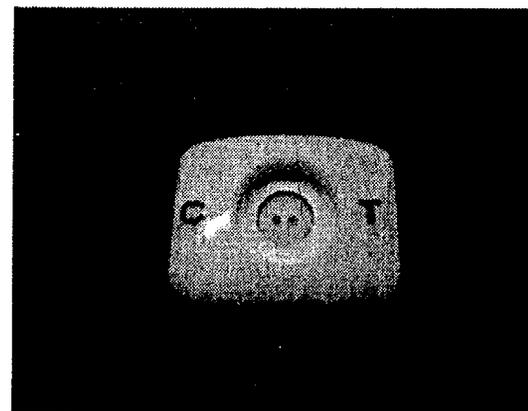


Unigold

Add whole blood or serum & buffer; read in 10 minutes

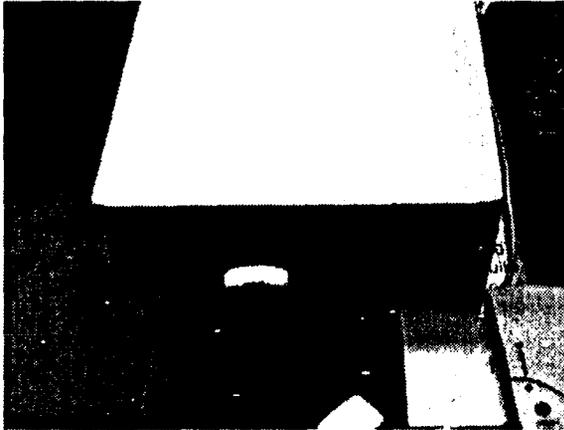


MedMira HIV 1-2

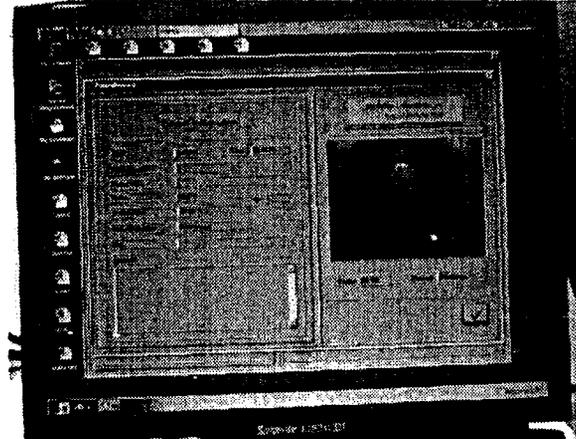


MedMira: Read results immediately

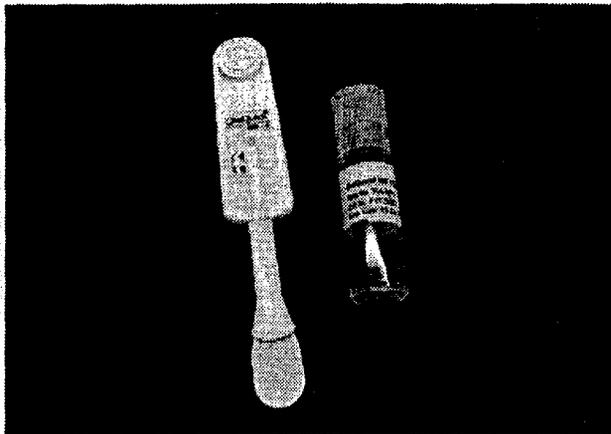




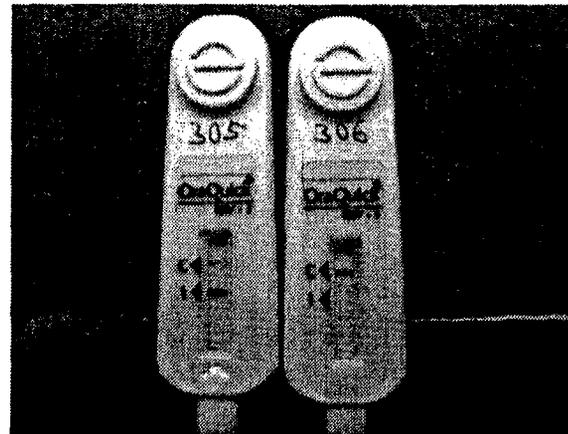
"Reader" to reduce subjective interpretation



Results can be stored for medical record

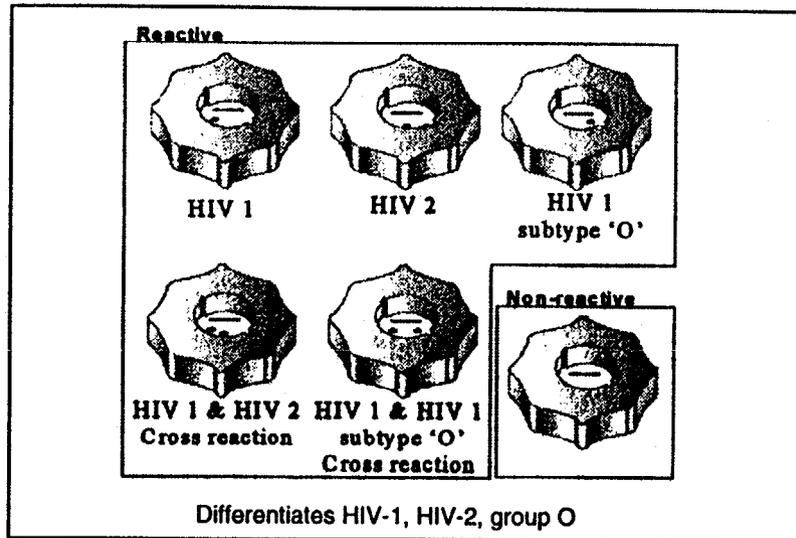


OraQuick: Whole blood, serum, oral fluid



Read results in 20 minutes





Rapid Test Performance: Serum		
	Sensitivity	Specificity
Determine	100%	98%
Hemastrip	98.5%	99.5%
Quix	100%	97.5%
Unigold	99.0%	96.0%
SUDS	97.9%	94.5%
HIV 1-2 EIA	-	95.1%

*196 HIV+, 200 HIV- repository sera*

Rapid Test Performance: Serum		
	Sensitivity	Specificity
Determine	100%	99.5%
OraQuick	100%	100%
MedMira	99%	100%
HIV 1-2 EIA	-	98.9%

*206 HIV+, 194 HIV- repository sera*

Rapid Test Performance: Plasma		
	<u>Sensitivity</u>	<u>Specificity</u>
Determine	100%	100%
Hemastrip	98.5%	100%
MedMira	96.7%	98.5%
OraQuick	100%	99.6%
Quix	99.7%	99.1%
Unigold	99.1%	99.8%
SUDS	99.7%	99.8%

*341 HIV+, 466 HIV- persons*

### Rapid Test Performance: Whole Blood

	False Negative	Sensitivity	False Positive	Specificity
Determine	0	100%	0	100%
Hemastrip	8	97.7%	0	100%
Quix	2	99.4%	5	98.9%
Unigold	16	95.3%	1	99.8%
SUDS (plasma)	4	98.8%	2	99.3%

*Prospective, 341 HIV+, 466 HIV- venipuncture specimens*

### CDC Multispot Evaluations

	HIV+ (n)	HIV- (n)	Sensitivity	Specificity
Bahamas/Trinidad (94)	474	3948	100%	99.97%
Honduras (92) Central lab	306	294	100%	100%
Honduras (92) regional labs	303	582	99.3%	99.0%
Honduras (92) test sites	37	1118	100%	100%
Bronx-Lebanon Hospital (94)	45	790	100%	99.1%



### NY Multispot Evaluations

	HIV+ (n)	HIV- (n)	Sensitivity	Specificity
HIV-2 study (98-99)	7,917	800	100%	99.5%
Newborn expedited (99)	3	184	100%	100%
Prospective (99)	364	616	100%	99.5%



### Examples of Discrepant Results

Ref	Determ blood	Hema blood	H-CDC plasma	Unigold blood	Unigold plasma	SUDS plasma	SUDS plasma	Oraquick plasma
110117	P	N,N	N	N,N	P	N,N,N	P	P
110132	P	N,N	P	N,N	N	P		P
110133	P	N,N	N	N,N	P	P		WP
110136	N	N	N	N		P,P	P	N
110137	P	N,N	N	N,N	P	P		WP
110151	P	N,N	P	P		P		P
110192	P	N	N	N	N	P		P
110308	P	P	P	N,N	N	N	P	P
220260	P	N	P	N	P	N	P	P
220282	I	N	N	N	N	N	N	N
220325	P	N,N	N	N,N	P	?	P	P
220354	P	P	P	N,N	P	P		
220370	P	P	P	N	P	P		P
220403	P	P	P	?	P	N	N	P



**Lessons: CDC International Studies**

- Both clients and staff prefer same-day results.
- Quality counseling can be provided.
- Combination-test algorithms yield accurate results.
- Same-day results help clients to receive immediate referrals and services they need.



**CDC Algorithm Evaluations**

South Africa	HIV+	HIV-	Sensitivity	Specificity
HemaStrip	66/67	204/205	98.5%	99.5%
Determine	67/67	204/205	100%	99.5%
D+H	65/67	202/201	98.5%	99.0%
HemaStrip positive only = 1		Determine positive only = 1		

Malawi	HIV+	HIV-	Sensitivity	Specificity
HemaStrip	168/169	720/720	99.4%	100%
Determine	169/169	718/720	100%	99.7%
H+D	168/169	718/720	99.4%	99.7%
HemaStrip negative only = 1		Determine positive only = 2		



**CDC Algorithm Evaluations**

Botswana	HIV+	HIV-	Sensitivity	Specificity
HemaStrip	96/97	81/81	98.97%	100%
Determine	97/97	81/81	100%	100%
D+H	96/97	81/81	98.97%	100%
Determine positive only = 1				

Uganda	HIV+	HIV-	Sensitivity	Specificity
HemaStrip	103/104	432/432	99.04%	100%
Determine	103/104	428/432	99.04%	99.07%
D+H	102/104	428/432	98.08%	99.07%
HemaStrip negative only = 1		Determine negative only = 1		



**Summary: Rapid HIV Testing**

- Rapid HIV tests are essential for early access to prevention, care and support services.
- The currently approved rapid test does not meet this need.
- Rapid testing with quality counseling is feasible and can help staff provide immediate care and support.
- Numerous accurate rapid tests exist.
- The need to approve simple rapid tests is urgent.



**Where do we go from here?**

- Concur on clinical trial requirements for HIV-1 screening indication.
- Encourage submission of PMA applications with available U.S. and foreign clinical trial information.
- Support any necessary additional trials.
- Recommend post-approval requirements for other indications (e.g., HIV-2, group O.)



In Press: AIDS Reviews, 2000

Rapid Tests for HIV Antibody  
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#### Abstract

Rapid HIV tests are widely used in resource-poor settings, especially in developing countries. The need for immediate HIV test results to make treatment decisions and to assist with prevention strategies portends their increased use in developed countries as well. Available data on the characteristics and performance of individual test devices are summarized from peer-reviewed journals and conference abstracts. Data from test manufacturers were not included unless corroborated by independent evaluations. Rapid HIV tests demonstrate sensitivities and specificities comparable to those of enzyme-linked immunoassays (ELISAs) currently used for screening. Algorithms comprised of a combination of two or more rapid tests produce HIV test results with predictive values comparable to those of the ELISA-Western blot combination. Rapid HIV tests offer additional advantages of low cost and same-day results and are likely to gain increasing acceptance for HIV screening and diagnosis in both developed and developing countries.

Keywords: HIV antibody testing, rapid serological assays, alternative confirmatory strategies

Voluntary human immunodeficiency virus (HIV) antibody testing and counseling services were initiated in March 1985, shortly after the introduction of the enzyme-linked immunoassay (ELISA) for the screening of donated blood. Initially, counseling and testing were intended to provide an alternative to the donation of blood as a means for high-risk persons to determine their HIV status. At that time, little was known about the prevalence and natural history of HIV infection. The benefit of screening blood to prevent HIV transmission from transfusions was clear, but the potential for false-positive results from the use of screening tests in low-prevalence populations raised questions about the usefulness of HIV antibody tests for screening [1]. The paradigm for HIV testing thus evolved to meet the requirements imposed by the need to protect the blood supply: tests with high sensitivity, suitable for batch processing of high volumes of specimens in centralized laboratories with specialized equipment.

The potential personal, medical, and public health benefits of testing for HIV antibody soon became clear [2]. The U.S. Public Health Service issued guidelines recommending ready access to HIV testing for persons who practiced high-risk behaviors [3]. Continued concerns about false-positive screening results [4] led to the implementation of a sequential two-test algorithm, comprising an ELISA screening test followed by Western blot or immunofluorescence assay as a supplemental test, to confirm HIV positivity. The U.S. Public Health Service recommended that no positive test results be given to patients until the screening test had been repeatedly reactive on the same specimen and the supplemental test had been used to validate those results [5]. The recommended tests require specialized equipment and technical expertise, and they cannot be completed in less than 24 hours. In practice, given the time necessary to transport specimens to a laboratory, perform the tests in batches, and transmit test results, tested persons typically must wait 1-2 weeks before they make a second visit to learn their test results.

ELISA and Western blot were not feasible for small laboratories in many developing countries where resources are limited and electricity may not be consistently available. These tests require many hours to perform, refrigeration, and sophisticated, expensive equipment [6]. A number of simple, rapid assays emerged to meet the demand in such countries both for blood screening and voluntary testing [7-11]. Numerous studies demonstrated that alternative confirmatory strategies using algorithms with combinations of screening tests produced reliable results, comparable to those of the standard ELISA and Western blot [12-15], and the United Nations Programme on HIV/AIDS - World Health Organization (WHO) currently recommends the routine use of combinations of screening tests for HIV screening, surveillance, and diagnosis (Table 1) [16,17]. Screening with combinations of rapid HIV tests proved to be less expensive than the ELISA/Western blot algorithm [15], and also made it possible to offer same-day test results. The lower cost made voluntary counseling and testing more feasible for developing countries, and availability of same-day results greatly increased the number of persons who learned their serostatus after testing [18,19]. Providers and clients reported high levels of satisfaction with rapid HIV tests [20].

Although more than 60 rapid HIV tests have been developed and used in various countries, only 2 have received approval from the Food and Drug Administration (FDA) for use in the United States. The first, Recombigen HIV-1 LA [21], was a latex agglutination test. As is true for many other agglutination tests, even technicians with extensive training had difficulty distinguishing reactive test results from the background granularity of the latex particles [11], and Recombigen was withdrawn from the U.S. market because of poor performance. Only one rapid test, SUDS (Single Use Diagnostic System for HIV-1), remains commercially available in the United States, and few are in use in other developed countries [22].

Four findings mandate the increased use of rapid HIV antibody diagnostics both in developing and developed countries for the benefit of public health [23]. First, antiretroviral therapy reduces occupational HIV transmission after percutaneous exposures [24] and reduces vertical transmission when used intra- or postpartum [25]. Access to immediate HIV test results could improve the judicious application of prophylactic regimens [26,27]. Second, many persons who are tested for HIV, including those who are HIV-infected, never receive their test results. [28-31]. Several studies suggest that persons who are aware they are HIV-infected adopt behaviors that make their transmission of HIV infection less likely [32-35], and rapid tests can substantially increase the number of persons who receive their test results [20,36,37]. Third, HIV infection in many persons who seek health care services remains undiagnosed [38-40]; rapid HIV tests could substantially assist with identifying these persons and providing them with essential medical and prevention services [40-44]. Finally, persons who are aware of their serostatus and ask about that of potential sex partners are very unlikely to choose a sex partner of opposite status [45]. The use of rapid tests as part of prevention strategies that promote the need for awareness of one's own and one's partner's infection status could reduce the sexual transmission of HIV considerably [46-50].

### Assay formats

Most rapid assays are in kit form that requires no other reagent, and many require no other specialized equipment. The three most common generic assay formats (Fig. 1) use particle agglutination, membrane immunoconcentration (flow-through) devices, or immunochromatographic (lateral-flow) strips. Particle agglutination assays typically require 10 to 60 minutes or more and must be used with serum or plasma. When a patient specimen containing HIV antibodies is mixed with minute HIV antigen-coated latex particles, cross-linking occurs and results in agglutination. Some devices enhance the visual agglutination reaction by using small, channeled, clear plastic cassettes. Flow of the specimen-particle mixture through narrowed areas in the channels promotes agglutination. Detection of weak agglutination can be difficult, and readers have been developed for some tests to reduce the inaccuracy introduced by subjective interpretation. The reagents often require refrigeration, and costs range from US\$2 to \$4 per test.

Membrane immunoconcentration devices employ solid-phase capture technology, which involves the immobilization of HIV antigens on a porous membrane. The specimen flows through the membrane and is absorbed into an absorbent pad. A dot or a line visibly forms on the membrane when developed with a signal reagent (usually a colloidal gold or selenium conjugate). Some tests allow the differentiation of HIV-1 from HIV-2 by applying antigens from these viruses to different sites on the membrane. The flow-through tests require several steps for the addition of specimen, wash buffers, and signal reagent, and they can usually be performed in 5 to 15 minutes. Most are used with serum or plasma, though some are equipped with a filter to allow the use of whole-blood specimens. The devices or reagents typically require refrigeration. Costs range from US\$4 to \$8 per test.

Immunochromatographic strips, the most recent development, potentially require only one step and incorporate both antigen and signal reagent into a nitrocellulose strip. The specimen is applied to an absorbent pad from which it is wicked, combines with signal reagent, and migrates through the strip. A positive reaction results in a visual line on the membrane where HIV antigen has been applied. A few of the strip tests also deploy different antigens at different locations to allow differentiation of HIV-1 group M, HIV-1 group O, and HIV-2 antibodies. A procedural control line that detects immunoglobulin G is usually applied to the strip beyond the HIV-antigen line. A visual line at the test and control sites indicates a positive test result, a line only at the control location indicates a negative test result, and the absence of a line at the control site means the test is invalid. Most lateral-flow tests require no additional equipment or refrigeration, and test results can be obtained in less than 15 minutes. Many can be used with whole blood, serum, or plasma, and some can be used with finger-stick specimens, saliva or oral fluids. In some lateral-flow devices, the test strip is encased in a plastic cartridge. Cost of these tests is usually less than US\$2.

Two other formats are used less commonly. Autologous red-cell agglutination tests require 5 minutes or less and detect HIV antibodies with a hybrid antigen-antibody reagent, which, when added to the red cells of the patient, agglutinates the patient's own red cells. Immunodot comb assays use a solid plastic matrix with "teeth" attached to one another, to which HIV antigen is fixed to capture HIV antibodies. Patient specimens are placed in wells spaced to accommodate each tooth of the comb device, which allows batch processing. The tests, which require less than 30 minutes to perform, are then developed with a signal reagent. Results for each specimen are visualized as a spot or a dot on the corresponding tooth.

Methods of antigen production (viral lysate, synthetic peptide, recombinant peptide) and the specific combinations of antigens differ with each individual assay. The devices are sometimes made by one company but distributed and sold under several brand names, which leads to confusion and makes it impossible to compile a comprehensive list. Because regulatory requirements and approvals are often minimal compared with those established by the U.S. FDA, it can sometimes be difficult to gauge the sensitivity and specificity of the tests with confidence. Some entrepreneurs use outlets such as the Internet to sell minimally evaluated tests of uncertain quality directly to the public. WHO, through its Programme on Health Technologies, periodically evaluates ELISAs and rapid tests that are available for bulk purchase by the public sector. The tests are performed on a panel of approximately 600 sera of diverse geographic origins and on 8 seroconversion panels [51]. Results of these evaluations are available at <http://www.who.int/pht>. Table 2 describes tests for which performance data are available from independent evaluations and tests for which preliminary data from active investigations show promise.

### Subtype detection

Paradoxically, rapid HIV tests are used most widely in parts of the world where non-B subtypes of HIV-1 group M, group O, and HIV-2 are found, but few systematic evaluations with sufficient numbers of specimens have been conducted to establish the capacity of the assays to detect these strains. Available data suggest that all subtypes of group M are adequately detected but that test performance is more variable with group O and HIV-2 strains [52-54]. Some tests include only HIV-1 antigens and detect only those HIV-2 strains with cross-reacting epitopes; others (e.g., Multispot) reliably detect and differentiate HIV-2 antibodies. Performance with group O strains is similar to that of ELISAs currently in use. Similarly sparse data from seroconversion panels demonstrate the analytic sensitivity of the rapid assays to be comparable to that of ELISAs currently licensed by the FDA in the United States [53,54].

### Discussion

The rationale for diagnostic testing has changed from clinical confirmation of suspected HIV disease to the potential for prevention and care afforded by knowing one's HIV status [17]. The HIV testing paradigm developed at the beginning of the epidemic, predicated on exquisite sensitivity, has served well for blood screening but may be less effective for diagnostic and surveillance purposes. A wide range of HIV antibody tests are available. The challenge today is to identify the most suitable assays for a given set of circumstances without compromising the reliability of test results.

Overall test sensitivity or specificity may be improved by using test combinations under one or more decision rules for resolving discordant results. For instance, the sensitivity of a single test can be improved if the combination is considered positive when either constituent test is positive. In this circumstance, the combined sensitivity reflects the best of the sensitivities achieved by either test. The penalty is specificity, which is reduced to the product of the individual specificities [55]. If the algorithm requires that both tests be positive, the combined sensitivity is the sum of the sensitivities of both tests minus 100, less than the sensitivity of either test alone. Despite improved sensitivity and specificity in each new generation of tests, few if any strategies involve only a single test for HIV screening. The usual strategy has been to screen with a low-cost highly sensitive test and then retest positive specimens with a second highly specific test.

Test sensitivity and specificity alone are not sufficient to establish optimal paradigms for HIV screening. Both logistics and economics pose significant challenges to accomplish the three main objectives of HIV antibody testing: (1) screening of donated blood for transfusion safety; (2) diagnosis of infection in individuals; and (3) epidemiologic surveillance of HIV prevalence. As examples, a single HIV screening test may be appropriate in some resource-poor settings if the alternative is no HIV testing at all [56]; initiating testing even when the full diagnostic algorithm cannot be completed can increase the number of persons who ultimately learn their HIV status because persons may be more likely to pursue further testing when advised of suspicious initial results [57].

As is true of any standard, the gold standard for HIV testing must incorporate the application for which it is intended. For gold itself, 24 karat is the standard for metallic purity, but a 14-karat alloy is used in jewelry because of its hardness and ability to retain shape. By a similar analogy, it is increasingly necessary to design alternative algorithms for HIV testing that take into account the many dimensions of the applications to personal and public health. Evidence suggests that many of the newer rapid HIV tests, which continue to improve, already perform as well as the ELISA and Western blot [58]. Although each test fails to detect antibody in occasional samples, combination-test algorithms can be employed which are as sensitive and specific as the ELISA/Western blot combination. It will be necessary to collect large amounts of data from diverse populations in settings of intended use to validate rapid tests against the standards with which we have become comfortable. While these evaluations are being conducted, it should be possible to perform screening with algorithms consisting of two or more rapid tests used simultaneously (with yet another test to resolve discordant results) so that individuals and public health can reap the benefits of newer technologies with little risk of unreliable results. Given the fast pace of development of rapid HIV tests, it is likely that such evaluations will need to be repeated frequently for the foreseeable future.

### Acknowledgements

The author gratefully acknowledges Niel T. Constantine, Ph.D., University of Maryland Institute of Human Virology; Mark Rayfield, Ph.D., Centers for Disease Control and Prevention, Division of AIDS, STD, and TB Laboratory Research; and Milton R. Tam, Ph.D., Program for Appropriate Technology in Health, for information on specific HIV tests included in Table 2, and Marie Morgan for invaluable assistance with this manuscript.

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Table 1. UNAIDS/WHO recommendations for HIV testing strategies

Objective		Prevalence	Strategy
Blood Screening		All	1
Surveillance		>10%	1
		≤10%	2
Diagnosis	Signs/symptoms	>30%	1
		≤30%	2
Diagnosis	Asymptomatic	>10%	2
		≤10%	3

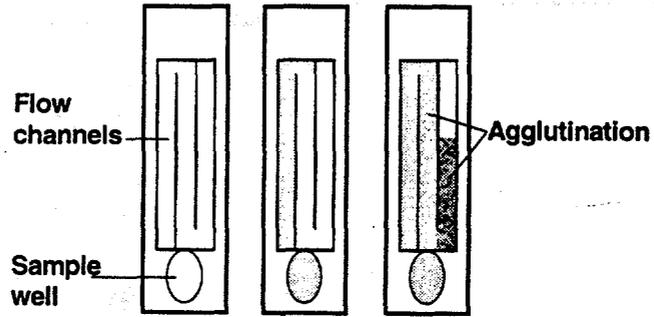
Strategy 1: Single screening assay. Reactive test is considered positive.

Strategy 2: Two screening assays. If initial test is reactive, test is repeated with second assay. Specimen considered positive only when both assays are reactive.

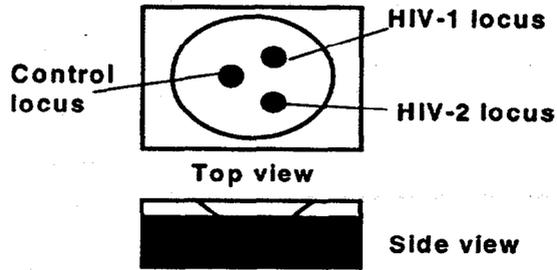
Strategy 3: Three screening assays. Specimen considered positive only when all three assays are reactive.

Figure 1. Schematic representation of rapid test assay formats

### Agglutination Device



### Flow-Through Device



### Lateral-Flow Device

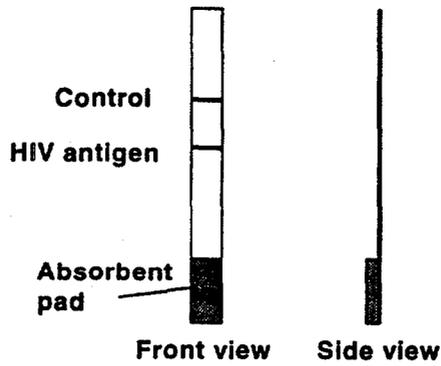


Table 2. Performance characteristics of rapid HIV tests

Manufacturer	Product	Principle	Sensitivity %	Specificity %	Comments
Abbott Laboratories Abbott Park, Illinois USA	Determine HIV-1/2/O	Lateral flow	97.9-100	100	Complexity: 1 Store at room temperature Whole blood, serum
	Retrocell HIV-1/2	Red cell agglutination	100	100	Complexity: 2 Store at 2-8°C
	SUDS HIV-1	Flow through	97.9-99.9	77.4-99.6	Complexity: 3 Store at 2-8°C
Agen Biomed Brisbane, Australia	SimpliRED HIV-1/2	Red cell agglutination	99.2	87.3	Complexity: 2 Store at 2-8°C
	MicroRED HIV-1/2	Particle agglutination	98.5	99.5	Complexity: 2 Store at 2-8°C
Bionor A/S Skien, Norway	Bionor HIV-1/2	Magnetic beads	100	98.8	Complexity: 3 Store at 2-8°C
BioRad Laboratories Redmond, Washington USA	Genie II HIV-1/2	Flow through	97.8-100	99.7-100	Complexity: 2 Store at 2-8°C
	Multispot HIV-1/2	Flow through	99.3-100	98.5-100	Complexity: 3 Store at 2-8°C
Cal Test Diagnostics Los Angeles, California USA	Red Dot HIV-1/2	Flow through	100	94.9	Complexity: 3 Store at 2-8°C
Epitope, Inc. Beaverton, Oregon USA	OraQuick	Lateral flow	100	100	Complexity: 1 Store at room temperature Whole blood, serum, saliva
Fujerebio Tokyo, Japan	Serodia HIV-1/2	Particle agglutination	100	98	Complexity: 3 Store at 2-8°C
Genelabs Technologies, Inc. Redwood City, California USA	HIV SPOT-1/2	Flow through	97-99	96-99	Complexity: 2 Store at room temperature

Manufacturer	Product	Principle	Sensitivity %	Specificity %	Comments
Sayvon Diagnostics Ltd. Ashdod, Israel	HIV SAV-1/2	Flow through	97.7	96.7	Complexity: 2 Store at room temperature
Hepatika Laboratories Mataram, Indonesia	Entebe HIV Dipstick	Immunodot comb	100	96.4	Complexity: 3 Store at 2-8°C
Immunochemical Laboratories Bangkok, Thailand	Dipstick HIV-1/2	Immunodot comb	100	98.2	Complexity: 2 Store at 2-8°C
J. Mitra & Co. New Delhi, India	HIV Tri-Dot	Flow through	99.6	99.7	Complexity: 3 Store at 2-8°C
MedMira Laboratories Halifax, Nova Scotia, Canada	MedMira HIV-1/2	Flow through	99.0-100	100	Complexity: 2 Store at room temperature Whole blood, serum
Orogencis Ltd. Yavne, Israel	DoubleCheck HIV-1/2	Immunodot comb	100	99.7	Complexity: 2 Store at room temperature
Ortho Diagnostics New Brunswick, New Jersey USA	HIVCHEK System 3	Flow through	98.2-100	98.8-100	Complexity: 3 Store at room temperature
Saliva Diagnostic Systems New York, New York USA	Hema-Strip HIV-1/2	Lateral flow	98.8-99.6	99.9-100	Complexity: 1 Store at room temperature Designed for finger stick
	Sero-Strip HIV-1/2	Lateral flow	98.4-99.9	99.6-100	Complexity: 2 Store at room temperature
Span Diagnostics Surat, India	CombAIDS Visual	Immunodot comb	100	88	Complexity: 2 Store at 2-8°C
Trinity Biotech Bray, Wicklow Ireland	Capillus HIV-1/2	Particle agglutination	98.6-99.9	98.2-99.6	Complexity: 2 Store at 2-8°C
	SalivaCard HIV	Flow through	98.9	98.8	Complexity: 2 Store at 2-8°C Saliva

Manufacturer	Product	Principle	Sensitivity %	Specificity %	Comments
	SeroCard HIV	Flow through	99.8-100	97.9-99.5	Complexity: 2 Store at 2-8°C
	UniGold HIV-1/2	Lateral flow	98.6-99.8	99.6-100	Complexity: 1 Store at 2-8°C Whole blood, serum
Universal Healthwatch Columbia, Maryland USA	Quix HIV-1/2/O	Flow through	100	99.8	Complexity: 2 Store at 2-8°C Whole blood, serum
Wiener Labratorios Rosario, Argentina	DIA HIV-1+2	Immunodot comb	99.6	99.4	Complexity: 2 Store at 2-8°C

## Notes to table:

Sensitivity and specificity entries with range represent published reports against multiple HIV-1/2 subtypes; entries with single figure represent data from a single independent evaluation, usually that of the WHO.

## Complexity rating:

1. Sample manipulation limited to application followed by addition of buffer reagent or wash; easily read
2. In addition to (1), centrifugation required; optional equipment beneficial