Published in final edited form as:
Clin Infect Dis. 2010 September 1; 51(5): 600–608. doi:10.1086/655762.

Clinical Impact and Cost of Monitoring for Asymptomatic Laboratory Abnormalities among Patients Receiving Antiretroviral Therapy in a Resource-Poor Setting

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Abstract

Background—Laboratory monitoring for toxicity among patients receiving antiretroviral therapy (ART) in less-developed settings is technically challenging and consumes significant resources.

Methods—We conducted a cohort study of the 1800 adult patients who initiated ART at the Haitian Study Group for Kaposi's Sarcoma and Opportunistic Infections (GHESKIO) in Haiti from 2003 to 2006, using baseline data to establish the prevalence and using follow-up data to establish the incidence of hepatitis, renal insufficiency, hyperglycemia, anemia, neutropenia, and thrombocytopenia. We determined how frequently routine (not symptom-driven) testing detected significant laboratory abnormalities and calculated the cost per disability-adjusted life year (DALY) averted by detection of these events in the asymptomatic stage, compared with a strategy of symptom-prompted testing only.

Results—Forty-eight patients (3.5%) had severe anemia at baseline testing and consequently did not receive zidovudine. Fifty-three patients receiving zidovudine therapy developed severe anemia during follow-up (incidence, 2.5 cases/100 person-years). Monitoring for asymptomatic anemia with hematocrit testing was cost-saving at baseline and had a cost-effectiveness ratio of US$317/DALY averted during follow-up; with a complete blood count, costs increased to US$1182 and $10,781/DALY averted, respectively. With glucose monitoring, 11 patients were diagnosed with new-onset hyperglycemia during follow-up (incidence, 0.7 cases/100 person-years), resulting in a cost-effectiveness ratio of US$9845 per DALY averted. Monitoring for asymptomatic hepatitis and renal insufficiency was expensive and rarely affected care.

Conclusions—Resource-poor countries should select which laboratory tests to perform on the basis of the cost-effectiveness of each test. This will depend on the national ART drug regimen and the prevalence of other comorbidities. Routine monitoring with multitest hematological and chemistry panels is unlikely to be cost-effective.

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Potential conflicts of interest. All authors: no conflicts.

Antiretroviral therapy (ART) significantly improves survival in patients with human immunodeficiency virus (HIV) and/or AIDS; however, these medications are associated with potentially life-threatening toxicities. Nevirapine may cause fatal hepatitis [1–5]. Zidovudine is a common cause of severe anemia [6–8]. Multiple ART medications are associated with hyperglycemia [9,10]. Because of the toxicities related to these and other ART agents, patients in industrialized countries are routinely monitored for asymptomatic laboratory abnormalities.

In resource-poor settings, there is limited capacity for laboratory monitoring of ART toxicity. Establishing this infrastructure—building laboratories, purchasing and maintaining laboratory equipment, training technicians, and establishing quality assurance and quality control programs—requires substantial financial and human resources. Evidence-based guidelines are needed to focus scarce resources on tests that will have an impact on care and require studies that evaluate the clinical benefits and costs of individual tests [11,12]. The objective of this study was to assess the clinical impact and cost-effectiveness of routinely monitoring for asymptomatic laboratory abnormalities among a cohort of patients receiving ART, compared with a strategy of testing only patients with symptoms of toxicity. The study was conducted in an outpatient clinic in Port-au-Prince, Haiti, and was approved by the local and academic partner institutional review boards.

METHODS

Study setting

The Haitian Study Group for Kaposi's Sarcoma and Opportunistic Infections (GHESKIO) is a nongovernmental organization that provides comprehensive HIV/AIDS care free of charge to all patients who present for care in Port-au-Prince. Haiti is the poorest country in the Western Hemisphere, with a population of 9.7 million and a per capita gross domestic product (GDP) of ~US$699 per year [13]. The HIV prevalence in Haiti is estimated at 2.2% in the adult population [14], with ~25,000 of ~120,000 HIV-infected patients nationwide currently receiving ART [15].

In March 2003, GHESKIO began offering universal ART based on World Health Organization (WHO) guidelines [16]. The standard first-line regimen is zidovudine, lamivudine, and efavirenz. Nevirapine is preferred over efavirenz for women of childbearing age. The outcomes of a subset of this cohort have been described previously [17].

Clinicians routinely monitor serum glutamic oxaloacetic transaminase (SGOT) and serum glutamic pyruvic transaminase (SGPT) for hepatitis, creatinine for renal insufficiency, glucose for hyperglycemia, and a complete blood count for anemia, neutropenia, and thrombocytopenia at ART initiation (baseline) and semiannually thereafter. The tests are also conducted if patients present with symptoms suggestive of toxicity, such as nausea, vomiting, jaundice, palpitations, shortness of breath, conjuctival pallor, urinary frequency, or blurred vision.

Study participants

The 1800 adult patients (aged ≥16 years) who had consecutive initiation of ART at GHESKIO from 1 March 2003 through 6 June 2006 were included in the study.

Clinical data collection

We retrospectively analyzed demographic data (age, sex, education, and income), clinical data (ART medications and concurrent tuberculosis infection), ART monitoring test results, and CD4 cell counts from electronic medical records and laboratory records for each study

participant. Tuberculosis was diagnosed using the case definition of the American Thoracic Society, as described previously [18,19]. All laboratory records were entered into a Microsoft Access database (Microsoft). After abnormal test results were identified in the database, the laboratory records were reviewed a second time by a different reviewer, and all abnormal values were confirmed. For each patient with abnormal values indicating hepatitis, renal insufficiency, hyperglycemia, anemia, neutropenia, or thrombocytopenia, a chart review was completed. We also reviewed data collected from a subset of patients enrolled from 23 December 2003 through 20 May 2004 to determine the proportion of tests with normal results that had been clinically prompted versus those that were routine [20].

Classification of laboratory abnormalities

GHESKIO serves as the national reference laboratory for HIV, tuberculosis, and sexually transmitted infections. Chemistries are performed on a VITROS DT60 II Chemistry system (Ortho-Clinical Diagnostics), and complete blood counts are performed with the Cell-Dyn 3200 (Abbott Diagnostics). Hematocrit testing may also be performed using a Micro-Hematocrit Centrifuge (LW Scientific).

We used the WHO guidelines to classify toxicity [16] (see Table 1 for details). We report all laboratory abnormalities for which clinicians should consider changing medication in accordance with WHO criteria.

Clinical impact of testing

To determine the clinical impact of routine monitoring for asymptomatic laboratory abnormalities, we first identified all abnormal test results and classified them as occurring at baseline or during follow-up, on the basis of the date of the test. We then categorized the tests as routine or clinically prompted. Tests were considered clinically prompted if the clinician checked a box in the medical record indicating a suspected toxicity or if such suspicion was identified elsewhere in the chart review. Next, we distinguished those abnormal tests that resulted in a change in medication (antiretroviral, tuberculosis, or diabetes medication) from those that did not. We defined an abnormal test as having a clinical impact if it resulted in a change in these medications. Finally, we used multivariate analysis to determine predictors of toxicity, defined by the WHO guidelines, to identify high-risk subgroups that might benefit from monitoring [16].

Tests with normal results were also identified from the laboratory records, but these records did not indicate whether they were conducted routinely or were clinically prompted. For tests with normal values, we estimated the proportion that would have been conducted routinely versus those that would have been clinically indicated from charts reviewed for a previous study [20], and we applied these ratios to the entire cohort.

Costs

Cost estimates were obtained using a microcosting approach in which each component of health care that is used is recorded, and a unit cost is applied to each [21]. For example, the cost of laboratory testing includes phlebotomy, personnel time, reagents, machines, and overhead. Treatment costs used in the cost-effectiveness analysis were from a previous published study of the cost of ART in Haiti [20]. Costs were measured from the health system perspective in 2004 US dollars.

Calculating cost per disability-adjusted life year

To evaluate the cost-effectiveness of routine laboratory monitoring, we followed methods established by the WHO Choosing Interventions that are Cost Effective (WHO-CHOICE) group, including calculating incremental cost-effectiveness ratios as cost per disability-

adjusted life year (DALY) and discounting both costs and DALYs at 3% annually [22]. A DALY is 1 year of "healthy" life lost to early mortality or morbidity due to a disease [23]. DALYs are calculated as the sum of the years of life lost (YLL) because of premature mortality and the years lived with disability from a disease, adjusted for the severity of that disability (YLD).

We calculated the DALYs that were averted by monitoring for asymptomatic laboratory abnormalities at baseline and semiannually, compared with a strategy of conducting laboratory testing only for patients with toxicity symptoms. We estimated from the published literature the risk of mortality and morbidity that would have occurred if asymptomatic laboratory abnormalities had not been detected and if use of the offending drugs had been stopped before patients developed clinical symptoms (see Table A1 in the Appendix, which appears only in the electronic version of the journal) to determine YLL and YLD. We also calculated the estimated health care system costs that would have been incurred to treat these clinical symptoms (Tables A2–A4 in the Appendix). The net cost of testing for asymptomatic laboratory abnormalities was the cost of routine tests for all asymptomatic individuals minus the estimated treatment costs averted by detection and treatment of the associated conditions in the asymptomatic stage. To calculate cost-effectiveness ratios for each test, we divided the net cost of testing in the cohort by the number of DALYs averted for that test.

Because laboratory tests are expensive, we conservatively assumed the maximum expected disease severity and duration of illness, to maximize the potential benefit of monitoring for laboratory abnormalities and to minimize the cost per DALY. We did not use age weights in calculating DALYs, because all patients were adults [22].

Statistical analysis

Data were entered into the Access database and then converted to SAS, version 9.1 (SAS Institute). Patients with severe (grade 3 or 4) laboratory abnormalities at baseline were excluded from all analyses of follow-up testing related to that laboratory test, including calculations of incidence and determinations of predictors of toxicity. We used the χ^2 or Fisher's exact test for all binary variables. We used the Wald confidence interval (CI) for adjusted odds ratios (ORs) and reported 95% CIs.

We conducted univariate and multivariate analyses using the following variables: education, income, age, sex, baseline weight, tuberculosis treatment, use of nevirapine in the first-line regimen, CD4 cell count, and presence of a mild or moderate abnormality at baseline in the predictor being evaluated. We used logistic regression with a stepwise selection method for all multivariate models; a *P* value of .30 was required for entry in the model, and a *P* value of .20 was required to stay in the model. There were no sets of variables in the reported model that showed signs of unacceptable colinearity.

RESULTS

Among the 1800 patients in the cohort, 980 (54%) were female, 1557 (87%) resided in Port-au-Prince, and the median age was 39 years (interquartile range [IQR], 32–46 years). The median CD4 cell count at entry in the study was 122 cells/mm^3 (IQR, 74–175 cells/mm^3). The median follow-up time was 910 days (IQR, 482–1185 days).

Of the patients, 1386 (77%) underwent at least 1 baseline test. During follow-up, 5232 laboratory panels (80%) were conducted, of a total of 6540 that would have been performed if every patient in care had routine testing every 6 months. All patients with reported laboratory abnormalities detected during follow-up testing had normal or mildly abnormal

baseline tests, as defined by WHO guidelines; there were no missing baseline values among these patients. Reasons for missed laboratory tests included missed clinic visits, laboratory equipment malfunction, physician error, and inadequate supply of laboratory reagents. Baseline tests were counted as missed if they were completed >6 weeks before initiation of ART. There were no significant differences in baseline variables between patients who had tests and those who did not.

Clinical Impact of Routine Testing

Liver function tests—Of 1242 patients, 13 (1%) had hepatitis at baseline SGOT/SGPT testing (12 had grade 2, and 1 had grade 3). Of 1571 patients who underwent semiannual follow-up testing, 20 (1.3%) developed hepatitis (13 had grade 2, 2 had grade 3, and 5 had grade 4); the incidence of hepatitis was 0.7 cases/100 person-years. Tuberculosis treatment was the only variable in the multivariate analysis that was associated with the development of hepatitis among patients receiving ART (OR, 3.4; 95% CI, 1.28–12.32; $P = .017$). Routine laboratory testing for asymptomatic hepatitis at baseline and during follow-up resulted in only a single patient changing medication. Table 1 describes the number of events detected by clinically prompted versus routine tests and the number of laboratory abnormalities that resulted in a treatment change.

Creatinine—Of 1206 patients, 10 (0.8%) had renal insufficiency at baseline testing (7 had grade 2, 1 had grade 3, and 2 had grade 4). Of 1461 patients who underwent follow-up testing, 9 (0.6%) developed renal insufficiency (all had grade 2); the incidence was 0.5 cases/100 person-years of follow-up. No risk factors for renal insufficiency were significant in the multivariate analysis. Routine testing at baseline and during follow-up resulted in a change in medication in a single patient.

Glucose—None of the 960 patients who had glucose levels measured at baseline had grade 2, 3, or 4 hyperglycemia. Of 1248 patients who underwent follow-up testing, 27 had hyperglycemia. Eleven patients received a diagnosis of new-onset diabetes; the incidence of diabetes was 0.7 cases/100 person-years. Six of these patients had no symptoms of hyperglycemia. Hyperglycemia was associated with higher income status (OR, 3.5; 95% CI, 1.10–4.76; $P = .028$) and improved in all patients after initiation of diabetes medications.

Hemoglobin—Of 1384 patients, 48 (3.5%) had grade 3 or 4 (severe) anemia at baseline testing (14 had grade 3, and 34 had grade 4). Of these patients, 25 (11 with grade 3 and 14 with grade 4 anemia) were asymptomatic—in each case, an alternative agent was substituted in place of zidovudine (Table 1). When patients with severe anemia at baseline were excluded and the analysis was limited to those taking zidovudine, 53 (4.4%) of 1204 patients developed severe anemia while receiving ART (15 had grade 3, and 38 had grade 4); the incidence of severe anemia was 2.5 cases/100 person-years.

In multivariate analysis, baseline mild or moderate anemia (OR, 1.33; 95% CI, 1.04–1.56; $P = .0174$) and tuberculosis co-treatment (OR, 2.40; 95% CI, 1.24–4.62; $P = .0089$) were associated with the development of severe anemia. Higher baseline hemoglobin was protective; for each additional gram of hemoglobin >10 g/dL, the relative risk of developing anemia was 0.79.

Neutrophils—Of 1370 patients, 4 (0.3%) had grade 3 or 4 (severe) neutropenia at baseline testing (2 had grade 3, and 2 had grade 4). Of 1256 patients who underwent follow-up testing, 19 (1.5%) developed severe neutropenia (13 had grade 3, and 6 had grade 4); the incidence of severe neutropenia was 0.9 cases/100 person-years. All patients who developed

neutropenia were asymptomatic (at baseline and during follow-up testing), and ART was not changed because of neutropenia for any of them.

Platelets—Of 1373 patients, 13 (0.9%) had grade 3 or 4 (severe) thrombocytopenia at baseline testing (9 had grade 3, and 4 had grade 4). Of 1336 patients who underwent follow-up testing, 14 (1%) developed severe thrombocytopenia (10 had grade 3, and 4 had grade 4); the incidence was 0.6 cases/100 person-years of follow-up. In 13 of 14 cases, the thrombocytopenia was asymptomatic; in all cases, it resolved without a change in medication.

Cost per DALY Averted by Monitoring for Asymptomatic Laboratory Abnormalities

Table 2 describes the costs for laboratory tests, which range from US$0.33 for hematocrit testing to US$6.00 for a complete blood count or liver function tests. Table 2 also shows the predicted complications that were prevented by routine performance of each laboratory test. For example, performance of liver function tests diagnosed a case of grade 3 hepatitis in an asymptomatic patient receiving tuberculosis cotreatment. Tuberculosis medication doses were decreased, and the hepatitis resolved. We assumed that this patient's condition would have progressed to severe (grade 4) hepatitis if the tuberculosis medication doses had not been adjusted. Table 2 also provides the DALYs associated with these complications and the estimated cost of medical care that would have been required to treat them if they had not been detected through routine monitoring.

Table 3 describes the cost and the cost per DALY averted by conducting routine laboratory testing, compared with a strategy of clinically prompted testing. Monitoring for asymptomatic anemia with hematocrit testing was cost-saving at baseline and had a cost-effectiveness ratio of US$317/DALY averted during follow-up. Monitoring for asymptomatic hematologic abnormalities with a complete blood count had cost-effectiveness ratios of US$1182/DALY averted at baseline and US$10,781/DALY averted during follow-up. Monitoring for hyperglycemia during follow-up had a cost of US$9845/DALY averted. Monitoring for other asymptomatic laboratory abnormalities at baseline or during follow-up cost from approximately US$15,000 to US$143,000/DALY averted.

DISCUSSION

The clinical impact and cost-effectiveness of routinely monitoring for asymptomatic laboratory abnormalities for patients receiving ART in Haiti vary considerably between tests. In our patients, nearly 5% developed zidovudine-related anemia, and monitoring for asymptomatic anemia with hematocrit testing was cost-saving at baseline and had a cost-effectiveness ratio of US$317/DALY averted during follow-up. Monitoring with complete blood count was less cost-effective than with hematocrit testing, because other hematological abnormalities (neutropenia and thrombocytopenia) had no clinical impact. Monitoring for asymptomatic hepatitis and renal insufficiency rarely affected care and had high (undesirable) cost-effectiveness ratios. In the DART study conducted in Uganda and Zimbabwe, the investigators found similar results, concluding that quarterly routine laboratory monitoring with biochemical and hematological panels was not cost-effective because there were no differences in adverse events or drug substitutions in first-line ART between study arms [31–33].

Our results suggest that resource-poor countries should select which laboratory tests to perform on the basis of the cost-effectiveness of each test. This will depend on the national ART drug regimen and the prevalence of other comorbidities, such as anemia, diabetes, hepatitis, and tuberculosis. Routinely monitoring with multitest hematological and chemistry

panels is unlikely to be cost-effective, even if the costs of individual tests are lower using a multitest panel, because test results are rarely positive.

According to the WHO, an intervention is considered “cost-effective” if the ratio of cost per DALY averted is <3 times a given country’s per capita GDP [34]. Using this threshold, monitoring for asymptomatic anemia is the only routine test that is cost-effective in Haiti, where the per capita GDP is ~US$699 [13]. Rates of anemia would be lower if ART medications that are not associated with anemia, such as tenofovir, are used. When decisions are made about which therapeutics to use, monitoring costs should be considered, in addition to the cost of supplying drugs.

Drug-induced hepatitis was uncommon in our population, and it was not cost-effective to monitor with liver function tests. The incidence of drug-induced hepatitis in our study was similar to rates reported in other resource-poor settings but was lower than those in middle- and high-income nations with higher rates of injection drug use and chronic hepatitis B and C [1–5,31,32,35–37]. Of note, patients in our cohort receiving tuberculosis medications were at increased risk for drug-induced hepatitis; therefore, targeted laboratory monitoring of patients receiving concurrent ART and tuberculosis medications may be cost-effective.

In comparison with routine monitoring for toxicity, CD4 cell count monitoring has been shown to be cost-saving, compared with symptom-based strategies, in southern Africa [38]. The cost-effectiveness of viral load testing in these settings will depend on test costs and virologic failure rates [38].

Our study was limited by being conducted in a single country. However, our findings clearly show that evidence-based policies for laboratory monitoring of patients receiving ART are needed in resource-poor countries. In Haiti, ~15% of the direct costs of providing ART to patients with AIDS are for laboratory testing [20]. Our findings suggest that much of this laboratory monitoring may not be an efficient use of resources. These results will vary on the basis of the ART regimen used in each country, and they will change as newer drugs are used. Other countries should undertake similar analyses, rather than committing a significant proportion of their ART budget to laboratory tests that rarely affect clinical management and that are not cost-effective.

Acknowledgments

We acknowledge Sidney Atwood, Heather Ribaudo, Emily Chu, Colin McCreight, Julia Carney, Sandra Apollon, and Lisette Dorvil for their generous assistance in statistical analysis, editing, and data retrieval.

Financial support. The project was supported in part by the National Institute of Allergy and Infectious Diseases (A158257), Fogarty International Center (TW006896, TW006901, TW00018, and TW007142), Harvard University (Centers for AIDS Research, National Institutes of Health P30 AI060354), and Frank Hatch Fellowship. Patient care was supported by the Global Fund to Fight AIDS, Tuberculosis and Malaria and by the US President’s Emergency Plan for AIDS Relief.

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Table 1

Clinical Impact of Laboratory Monitoring in Adult Patients Receiving Antiretroviral Therapy in Haiti

Test	Total no. of tests conducted	Laboratory abnormalities[a] detected by clinically prompted tests		Laboratory abnormalities[a] detected by routine tests	
		No treatment change	Treatment change	No treatment change	Treatment change
Tests conducted at baseline					
SGOT/SGPT	1242	3	1	8	1
Creatinine	1206	3	3	3	1
Glucose	960	0	0	0	0
Hemoglobin (CBC)	1384	0	23	0	25
Neutrophils	1370	0	0	4	0
Platelets	1373	0	0	13	0
Tests conducted at follow-up					
SGOT/SGPT	4684	2	8	10	0
Creatinine	4456	2	0	7	0
Glucose	3877	0	5	16	6
Hemoglobin (CBC)	5453	2	35	2	14
Neutrophils	4945	0	0	19	0
Platelets	5347	0	1	13	0

NOTE. Treatment change was defined as a change in antiretroviral, tuberculosis, or diabetes medication. CBC, complete blood count; SGOT/SGPT, serum glutamic oxaloacetic transaminase/serum glutamic pyruvic transaminase.

[a]Laboratory abnormalities are defined as follows: grades 2, 3, and 4 hepatitis are SGOT/SGPT elevations of >2.5 to 5 times the upper limit of normal (×ULN), >5 to 10 ×ULN, and >10 ×ULN, respectively. Grades 2, 3, and 4 renal insufficiency are creatinine elevations of >1.5 to 3 ×ULN, >3 to 6 ×ULN, and >6 ×ULN, respectively. Grades 2, 3, and 4 hyperglycemia are glucose levels of 161–250, 251–500, and >500 mg/dL, respectively (patients were tested in the nonfasting state). Grades 3 and 4 anemia are hemoglobin levels of 6.5–6.9 and <6.5 g/dL, grades 3 and 4 neutropenia are neutrophil counts of 500–749 and <500 neutrophils/mm^3, and grades 3 and 4 thrombocytopenia are platelet counts of 20,000–49,999 and <20,000 platelets/mm^3, respectively.

Clin Infect Dis. Author manuscript; available in PMC 2010 December 28.

Table 2

Monitoring Test Costs, Disability-Adjusted Life Years (DALYs), and Costs Averted per Case Detected

Test, cost per test; complications avoided by detection	Probability that complication is fatal	Disability weight (duration, years)	DALYs averted per abnormal laboratory test result detected[a]	Cost of medical care averted[a]	References
SGOT/SGPT, $6.00					
Progression to severe hepatitis from tuberculosis drugs[b]	0.047	0.209 (0.25)	0.394	$477.00	[23–25]
Creatinine, $3.00					
ART overdosage (ART doses lowered because of renal failure)	0.000	0.086 (0.25)	0.022	$53.00	[23,26]
Glucose, $3.00					
Blindness	0.000	0.600 (4.2)	0.136[c]	$360.00	[23,27]
Renal failure		0.086 (4.2)	0.007[c]		
Amputation		0.155 (4.2)	0.013[c]		
CBC (hemoglobin, neutrophils, and platelets), $6.00					
Grade 3 anemia	0.000	0.093 (1.0)	0.090	$43.00	[6,23,28,29]
Grade 4 anemia	0.009	0.255 (1.0)	0.311	$74.00	
Neutropenia	0.028	0.000 (0.0)	0.205	$101.00	
Thrombocytopenia	0.008	0.000 (0.0)	0.059	$75.00	
Hematocrit (spun), $0.33					
Grade 3 anemia	0.000	0.093 (1.0)	0.090	$43.00	[6,23]
Grade 4 anemia	0.009	0.255 (1.0)	0.311	$74.00	

NOTE. All dollar amounts are in US dollars. DALYs are calculated assuming life expectancy of 8.4 years [30]. ART, antiretroviral therapy; CBC, complete blood count; SGOT/SGPT, serum glutamic oxaloacetic transaminase/serum glutamic pyruvic transaminase.

[a] For calculations of DALYs averted, see Table A1 in the Appendix (which appears only in the electronic version of the journal), and for calculations of medical costs averted by early detection, see Tables A2–A4 in the Appendix.

[b] Note that ART-related liver disease did not result in any changes in medication.

[c] Assumes 0.066 probability of blindness, 0.023 probability of renal failure, and 0.025 probability of amputation; total DALYs averted are 0.156 per case of diabetes detected.

Table 3

Costs and Costs per Disability-Adjusted Life Year (DALY) Averted by Routine Monitoring Tests

Test	Events detected by routine tests	DALYs averted by routine tests	Cost of all routine tests	Cost of care averted by routine tests	Cost of all routine tests minus the cost of care averted	Cost per DALY averted by routine tests (95% CI[a])
Tests conducted at baseline						
SGOT/SGPT	1	0.394	$6552	$477	$6075	$15,419 ($2769–$70,599)
Creatinine	1	0.022	$3198	$53	$3145	$142,955 ($25,789–$670,519)
Glucose	0	0	$2631	$0	$2631	No change (≥$5061)
CBC (hemoglobin, neutrophils, and platelets)	25[b]	5.344	$7824	$1509	$6315	$1182 ($802–$1810)
Hematocrit (spun)[c]	25[b]	5.344	$430	$1509	−$1079	Cost-saving
Tests conducted at follow-up						
SGOT/SGPT	0	0	$27,600	$0	$27,600	No change (≥$19,036)
Creatinine	0	0	$13,176	$0	$13,176	No change (≥$170,455)
Glucose	6	0.936	$11,373	$2158	$9215	$9845 ($4583–$25,970)
CBC (hemoglobin, neutrophils, and platelets)	14[d]	2.807	$31,080	$819	$30,261	$10,781 ($6459–$19,376)
Hematocrit (spun)[c]	14[d]	2.807	$1709	$819	$890	$317 ($190–$570)

NOTE. All dollar amounts are in US dollars. CBC, complete blood count; CI, confidence interval; SGOT/SGPT, serum glutamic oxaloacetic transaminase/serum glutamic pyruvic transaminase.

[a] The 95% CI represents the cost per DALY averted calculated for the upper and lower bounds of the 95% confidence interval for the number of events detected by a routine test.

[b] Includes 11 cases of grade 3 anemia (0.090 DALYs averted per case detected) and 14 cases of grade 4 anemia (0.311 DALYs averted per case detected); neutropenia and thrombocytopenia were excluded from further analyses because no cases were detected through routine testing.

[c] Assumes the same test performance as hemoglobin (CBC).

[d] Includes 7 cases of grade 3 anemia and 7 cases of grade 4 anemia.