Implementation of low-cost, point-of-care cardiovascular diagnostics by non-healthcare professionals in rural Uganda

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Introduction

- Non-communicable diseases (NCDs) account for the majority of adult deaths worldwide, and 80% of these deaths occur in low and middle-income countries (LMICs).
- The burden of NCDs in LMICs is predicted to grow with improvements in sanitation and infectious disease control, and will be altered by local diet, smoking rates, and HIV co-infection.
- There is a critical need to identify and implement low-cost, well-validated diagnostic tests to elucidate the epidemiology of NCDs, and enable diagnostic monitoring and therapeutic interventions.
- Tests that enable non-healthcare professionals to lead care provision will augment the scalability of this strategy.
- In 2010, the WHO recommended a package of essential noncommunicable disease technologies for use in low-resource settings including a digital blood pressure measurement device, electrocardiograph, and glucometer.
- Validation of such tools in appropriate settings will be crucial to developing a strategy for strengthening health systems to address the growing burden of NCDs.

We recently completed implementation and evaluation of a bundle of point-of-care, low-cost diagnostics for NCD measurement in rural Uganda. The objective was to assess the feasibility, reproducibility, and cost of testing in a resource-poor setting for a variety of cardiovascular conditions including hypertension, diabetes, and subclinical atherosclerosis.

Aims

1. Evaluate the feasibility of non-healthcare professionals to perform tests for hemoglobin A1c, blood pressure, and ankle-brachial index.
2. Assess the quality of carotid ultrasound imaging performed by a non-sonographer.
3. Estimate the per-patient cost of administering a bundle of point-of-care cardiovascular diagnostic tests.

Methods

Design
- Baseline measurement of a longitudinal cohort study in rural, southwestern Uganda
- Cohort 1: HIV-infected persons on antiretroviral therapy at the Mbarara Regional Referral Hospital in Mbarara, Uganda
- Cohort 2: Age and gender-matched HIV-uninfected persons from the clinic catchment area.
- Three non-healthcare professional Ugandan staff completed a two-week intensive course to perform a series of point-of-care cardiovascular assessments

Carotid ultrasound imaging protocol
- Automated blood pressure
- Portable electrocardiogram (ECG)
- Ankle-brachial index (ABI)
- Hemoglobin A1c testing (HbA1c)
- Anthropometric measurements
- An American medical student was trained through the University of Wisconsin Atherosclerosis Imaging Research Program to perform measurement of carotid intima-media thickness (CIMT) according to the American Society of Echocardiography consensus guidelines.
- The study received ethics approval from the Mbarara University of Science & Technology and Partners Healthcare. All participants provided written informed consent.

Statistical Analysis
- We assessed the quality and feasibility of each measurement by:
  1. Proportion of valid hemoglobin A1c results
  2. Proportion of interpretable carotid ultrasound images as graded by a board-certified vascular cardiologist using the University of Wisconsin CIMT image quality assessment scale (1 = good, 2 = average, 3 = not suitable).
  3. Correlation between brachial blood pressure measurements and automated systolic blood pressure measurements.

- Analysis was conducted in Stata version 13.

Results

105 HIV-infected and 100 HIV-uninfected individuals were enrolled in the study. In total, there were 101 males (49.3%) and 104 females (50.7%) with a median age of 49 years.

Diabetes screening
- None of the 205 total HbA1c tests were invalid. The coefficient of determination between the HbA1c and fasting plasma glucose levels was 0.65.

Carotid intima-media thickness quality assessment
- Of the 1213 CIMT images reviewed, 1024 (84.4%) were found to be of adequate quality for interpretation (average score: 1.4 ± 0.7). 98% of participants had at least 4 valid images necessary to calculate a mean CIMT.

Blood pressure screening
- The right and left brachial blood pressure measurements had coefficients of determination of 0.78 and 0.71, respectively, with the automated systolic blood pressure measurements.

Cost estimates
- Based on an estimate patient volume of 1,000 patients per year and measurement for 3 years, the cost for this array of tests, including capital equipment, would be approximately $28 per patient.

Discussion

Following a modified WHO framework (Box 1), we are able to outline the appropriateness of our diagnostics:

Affordability
- In Uganda, estimated annual per-patient lab costs for HIV care is 111,000 Ugandan shillings, or about $45 USD.
- Over three years the per-patient costs of our bundle of tests would be $28 USD, which is within range of the Ugandan HIV lab costs or similar NCD diagnostics done in the US.

Validity
- All HbA1c tests were valid and results correlated with fasting plasma glucose levels.
- Carotid ultrasound has been shown to be a noninvasive, sensitive, and reproducible tool for assessing cardiovascular disease risk.
- Average carotid ultrasound image quality score was 1.4 ± 0.7, compared to 1.9 ± 0.1 from a previous assessment of non-sonographer clinicians in the United States.
- Comparisons of automated blood pressure measurements and manual measurements showed good correlation.

User-friendliness
- Task-shifting has been identified as a major approach to strengthening health systems and increasing access in resource-poor areas.
- Able to train three Ugandan non-healthcare for two weeks and an American medical student on performing carotid ultrasound for two days.

Rapid treatment
- All participants with a blood pressure ≥140/90 or an HbA1c ≥6.5% were referred to the Hypertension Clinic and Diabetes Clinic, respectively.
- At the Mbarara Regional Referral Hospital.
- Linking rapid diagnosis to treatment will need to be further investigated.

Portability
- All electronic equipment used were portable, easily transported manually, and battery-operated with the option for charging when available.

Conclusion

- Low-cost, portable, and well-validated point-of-care tests for NCDs can be implemented by non-medical professionals in LMICs.
- Implementation evaluations should be pursued to assess the large-scale feasibility, scalability, and impact of this strategy.

References

Acknowledgements
This work was supported by the National Institutes of Health and the Doris Duke Charitable Foundation through a grant supporting the Doris Duke International Clinical Research Fellows Program at Harvard Medical School. June-Ho Kim is a Doris Duke International Clinical Research Fellow. Special thanks to Ruth Sentongo, Shailash Abasabwonya, Dennis Kyoimuhendo, Alan Babweteera, Carol Benoit, Lisa Hirshorn, and Blada Ojikutu.