FIND
Because diagnosis matters

LANDSCAPE OF

POINT-OF-CARE DEVICES FOR TESTING OF CARDIOMETABOLIC DISEASES

FEBRUARY 2020

CONTENTS

ABBREVIATIONS AND KEY DEFINITIONS

ACC/AHA	American College of Cardiology/American Heart Association
ACR	Albumin-creatinine ratio
ALP	Alkaline phosphatase
ALT/GPT	Alanine aminotransferase
AMY	Alpha-amylase
AST/GOT	Aspartate aminotransferase
BUN	Blood urea nitrogen
CE	Certification Europe (conformité européenne)
CK	Creatinine kinase
Cl	Chlorine
CKD	Chronic kidney disease
CLIA	Clinical laboratory improvement amendments
CRE(A)	Creatinine
CRP	C-reactive protein
CVD	Cardiovascular diseases
EDL	Essential Diagnostics List
eGFR	Estimated glomerular filtration rate
FDA	U.S. Food & Drug Administration
FIND	Foundation for Innovative New Diagnostics
FORD	Free oxygen radicals defense
FORT	Free oxygen radicals test
GGT	Gamma-glutamyl transpeptidase
GLU	Glucose
HB	Haemoglobin
HCT	Haematocrit
HCY	Homocysteine
HDL	High density lipoprotein
IAS	International Atherosclerosis Society
IDF	International Diabetes Federation
INR	International normalized ratio
IVD	In vitro diagnostics
LDL	Low density lipoprotein
K	Potassium
KDIGO	Kidney Disease Improving Global Outcomes
LMIC	Low- and middle-income country
Na	Sodium
NCD	Non-communicable diseases
NGSP	National Glycohemoglobin Standardization Program
PEN	Package of Essential Noncommunicable Disease Interventions
PHC	Primary health care
POC	Point of care
PT	Prothrombin time

RBC	Red blood cell count
RCT	Randomized control trial
RFID	Radio frequency identification
SDG	Sustainable Development Goals
SRA	Stringent regulatory approval
TBA	Total bile acid
TBIL	Total bilirubin
TCH	Total cholesterol
TCO2	Total carbon dioxide
TFDA	Taiwan FDA
TG	Triglycerides
TPP	Target product profile
WHO	World Health Organization

Cardiometabolic – Pertaining to cardiovascular diseases and associated metabolic disorders, such as diabetes

In vitro diagnostic tests – Tests that are used for in vitro evaluation of specimens derived from the human body to provide information for screening, diagnosis, or treatment monitoring purposes.

Parameter – Marker, analyte or substance, e.g. glucose

Multi-parameter device – Diagnostic device that can test for multiple analytes either simultaneously or sequentially

Primary care – The part of a health services system that assures person-focused care over time for a defined population, accessibility to facilitate receipt of care when it is first needed, comprehensiveness of care in the sense that only rare or unusual manifestations of ill health are referred elsewhere, and coordination of care such that all facets of care (wherever received) are integrated [1].

Point-of-care testing - Testing that is performed in close proximity to where the patient is receiving care. Testing is performed by health professionals and results are typically available relatively quickly.

DISCLAIMER

Although all efforts have been made to ensure that the present landscape provides an accurate and comprehensive overview of cardiometabolic devices for use at the POC in primary care facilities, some devices may not have been identified. The mention of specific companies or of certain manufacturers' products does not imply that they are endorsed or recommended by the Foundation for Innovative New Diagnostics (FIND), the World Health Organization (WHO), or any global humanitarian aid organisation or individual involved in defining the scope and content of this report.

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EXECUTIVE SUMMARY

With the rise of cardiovascular diseases (CVD) and diabetes, the global disease burden is shifting towards non-communicable diseases (NCDs). An increasing number of low- and middle-income countries (LMICs) are currently experiencing the double burden of infectious and non-communicable diseases [2]. CVD and diabetes alone make up more than two thirds of the global burden of the four most common NCDs, including chronic respiratory diseases and cancer [3].

In order to facilitate a patient-centred approach to healthcare, there is an urgent need to ensure that primary healthcare (PHC) facilities in LMICs are capable of addressing diagnosis and monitoring of both infectious and non-communicable diseases at the point of care.

While several technology landscapes of (multi-) disease diagnostics for infectious diseases at different levels of care are available [e.g. 4, 5], landscapes for NCD diagnostics to address cardiometabolic disorders are lacking. As a result, the Foundation for Innovative New Diagnostics (FIND), together with technical inputs from the World Health Organization (WHO), developed this landscape of multi-parameter point-of-care (POC) devices capable of supporting diagnosis and monitoring of cardiometabolic diseases at PHC facilities.

Cardiometabolic risk factors include raised blood pressure, raised blood glucose, raised blood lipids, excess weight and obesity. The WHO Package of Essential Noncommunicable Disease Interventions for primary health care in low-resource settings (WHO PEN package, [6]), as well as the WHO Model List of Essential In Vitro Diagnostics (EDL, [7]), include several interventions that can be used to detect and manage cardiometabolic risk.

In consultation with clinical stakeholders from a range of global humanitarian aid organizations, FIND and WHO set the scope of minimal biochemical parameters to be available in part or in full on a cardiometabolic POC device for this landscape – to lipids/lipoproteins, glucose, glycated haemoglobin (HbA1c) and serum creatinine. The inclusion of HbA1c and serum creatinine serve to support the management of diabetes and chronic kidney disease.

Eligibility criteria for inclusion of a device in the landscape included the capability to run the test for at least two of these parameters from ready-to-use cartridges or test strips on small benchtop devices[1]. Devices had to be intended for use in primary care settings without the need for dedicated laboratory infrastructure (though the devices are also sometimes used at higher levels of care).

Eligible devices were identified through a combination of desk research, an open request for information and direct conversations with manufacturers at two international trade fairs for medical technologies. Initially, more than 50 devices were identified, of which 21 met all eligibility criteria.

Manufacturers were asked to provide information on their full cardiometabolic tests menu, reagent properties, regulatory status and global presence, device workflow and physical features, software capabilities, and service and support. If a manufacturer did not respond, the required information was obtained from the manufacturer's website if available.

Nineteen of the final 21 devices have tests for two or three of the minimal parameters available and sixteen of these devices feature tests for further cardiometabolic parameters. Two devices have tests for all minimal parameters available, though only one of them via a connected companion device.

[1] Devices using cuvettes with bulk-reagents, as well as hand-held devices measuring only blood glucose and lipids, were not included.

All the devices and reagents with available information in the landscape are approved by a stringent regulatory authority (SRA) and all manufacturers have a presence or distribution capabilities in LMICs. None of the reagents require freezing for shipping or storage and many are shipped and stored at room temperature; however, most of the reagents do require refrigeration for long-term storage. Most devices do not require very tight environmental storage or operating conditions.

The more recently developed tools have sophisticated software features such as bidirectional connectivity for communication with laboratory information systems and electronic medical records. Tests involve a minimal number of steps to be operated and many only require minimal training, meaning a non-laboratory-trained user can follow the instructions and operate them correctly.

Pricing information was not included in the landscape as devices and reagents are often sold through distributors; as sales channels around the world and prices vary significantly, a meaningful comparison of prices would not be feasible.

The landscape also includes a summary of the biological basis for the use of each of the minimal parameters for diagnosis and management, a description of their potential utility in LMICs, a comparison with laboratory-based tests, and information on relevant international guidelines.

INTRODUCTION

AIM OF THE LANDSCAPE

Cardiometabolic diseases lead to the highest burden of disease and death worldwide [8, 9], especially in low- and middle-income countries (LMICs), where risk factors are rising with changes in diet and living standards, and appropriate patient management is not always available or accessible [10].

The reduction of premature mortality from cardiometabolic and other non-communicable diseases are specific targets of the United Nations' Sustainable Development Goals (SDGs) and the World Health Organization's (WHO) Global Action Plan for the Prevention and Control of NCDs [11, 12]. The WHO document on "Stronger Collaboration, Better Health: Global Action Plan for Healthy Lives and Well-being for All" cites a cardiometabolic panel for cardiovascular disease (CVD) and diabetes as an "indicative example of evidenced-based innovation(s) that require(s) collective action to be brought to scale" to achieve the SDGs [13].

Several in vitro diagnostic (IVD) manufacturers have developed solutions to address the need for comprehensive, integrated responses to cardiometabolic risk and disease diagnosis and monitoring, and LMICs are increasingly looking to adopt them. However, as the available biochemical parameters and operational characteristics of the devices vary, it can be challenging for countries to decide which option best meets their needs.

In consultation with WHO, the Foundation for Innovative New Diagnostics (FIND) compiled this technology landscape of IVD multi-parameter point-of-care (POC) devices for the detection of a range of cardiometabolic markers to support in-country decision makers in their choice of fit-for-purpose technologies for diagnosis and monitoring of cardiometabolic risk and diseases in primary care settings.

Input on diagnostic parameters and technical features to be collected for the devices was sought from clinical and laboratory stakeholders from WHO and global humanitarian aid organizations.

Going forward, FIND is developing a target product profile (TPP) for point-of-care cardiometabolic devices for the use at primary care settings in LMICs, to be used in conjunction with this landscape to evaluate devices for their fit with TPP requirements.

SCOPE AND METHODOLOGY

This landscape focuses on POC IVD devices, capable of testing biochemical parameters for cardiometabolic diseases, to be used in primary care settings.

Cardiometabolic parameters are used to diagnose, prevent and manage cardiovascular diseases (CVD) and metabolic disorders. A well-defined risk factor for CVD is hyperlipidaemia [14], diagnosis of which requires the measurement of blood lipids. Important metabolic disorders are diabetes and renal impairment, the former requiring the ability to detect and determine glucose and glycated haemoglobin A1c (HbA1c) levels in the blood, and the latter the levels of creatinine.

The WHO PEN package lists the tests for hyperlipidaemia, diabetes and renal impairment as essential NCD investigations in primary care [6], and management of blood lipids, glucose levels and chronic kidney disease plays an essential role in the WHO HEARTS Technical Package for cardiovascular disease management [15]. For the purposes of this landscape, these parameters were defined as "minimal set". All devices included were required to be able to measure at least two of the minimal parameters (**Table 1**).[2] Liver function and other tests are covered as an add-on in the landscape, depending on the parameters measured by each device. Parameters could be measured by individual tests or as part of a panel (testing for a fixed combination of several parameters in a single cartridge).

Table 1. Minimal set of parameters required on the device for inclusion and additional parameters available per device listed in the landscape

Minimal parameters (at least two required)	Additional parameters (listed if available)
Lipids/lipoproteins (total cholesterol, LDL, HDL and triglycerides)	Liver function and other tests: ALT, AST, ALP, GGT, albumin, bilirubin, glycated albumin
Glucose	Urine test: microalbuminuria, urine creatinine, urine ACR, ketones, glucose
HbA1c	Haematocrit, troponin, blood gases
Serum creatinine	Sodium, potassium, creatinine kinase, haemoglobin + other tests that might be available on a particular device

LDL: Low-density lipoprotein; HDL: High-density lipoprotein; HbA1c: Haemoglobin A1c; ACR: Albumin-creatinine ratio; ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; ALP: Alkaline phosphatase; GGT: Gamma-Glutamyl Transpeptidase

All devices included in the landscape are intended for use in primary care settings without the need for dedicated laboratory infrastructure. All tests are designed to be run from ready-to-use cartridges or test strips on small benchtop devices (**Table 2**).

Table 2. Technical criteria required for inclusion in the landscape

Technical criteria
Self-contained reagent cartridges or strips, containing all reagents to be used to run specific tests without additional reagent preparation steps (Devices using cuvettes with bulk-reagents were not included)
Ability to accept whole blood was preferred where technically possible, however this was not an exclusion criteria
Intended to be used without laboratory infrastructure

[2] Handheld devices measuring only lipids and glucose were excluded due to the large number of devices available

Several approaches were taken to identify devices that met the scope described above. This included investigation of market reports, company websites, and industry publications (e.g. the College of American Pathologists' CAP Today: Chemistry and immunoassay analyzers for POC and low-volume labs, 2019), as well as a broad keyword-based online search (employing a combination of a wide range of applicable keywords, e.g. "cardiometabolic testing", "near patient", "point-of-care", "bench-top test/instrument/device", "lipids/HbA1c/glucose/creatinine", and others). Furthermore, two international trade fairs for medical technologies were scouted opportunistically for suitable devices (American Association for Clinical Chemistry conference and MEDICA, both in 2019) and FIND published a Request for Information on the organization's website (July/August 2019 [16]) to provide manufacturers without strong online presence the opportunity to respond.

Through these approaches, 54 devices were identified initially, of which 21 met the requirements for available biochemical parameters (Table 1) and technical criteria (Table 2). The search also highlighted the availability of a large number of hand-held devices only measuring lipids and glucose. These were not included in the landscape as it would not have been possible to provide a truly comprehensive or near-complete overview.

Manufacturers were contacted to ensure that details relating to each device were correctly represented in the landscape. If no response was received from a manufacture directly, details on product characteristics were obtain from the manufacturer's website.

Characteristics for each device assessed were: reagent menu and storage conditions, regulatory approval, company footprint in LMICs, workflow features, software capabilities, physical features, and service and support.

For background information, the landscape of the POC devices is accompanied by a brief review report summarizing the biology of the minimal set of parameters and their clinical utility, advantages and disadvantages and related international guideline recommendations. The POC alternatives are compared with laboratory tests, and the use of POC tests in LMICs is discussed.

Table 3 gives an overview of identified cardiometabolic POC devices, range of parameters, and reagent regulatory status, and section 4 provides detailed specifications for each device.

Table 3. Overview of the 21 cardiometabolic POC devices included in the landscape

Devices	Manufacturer (country)	Parameters					SRA[a]	
		Lipids [b]	Glucose	HbA1 [c]	Creatinine	others [c]	US FDA [d]	CE
Piccolo Xpress®	Abbott Laboratories (USA)	○●	●	—	●	●		
Afinion™ AS100 Analyzer	Abbott Laboratories (USA)	○	—	○	ACR	CRP		
Afinion™ 2 Analyzer	Abbott Laboratories (USA)	○	—	○	ACR	CRP		
Cholestech LDX™ Analyzer	Abbott Laboratories (USA)	○●	●	—	—	—		
i-STAT	Abbott Laboratories (USA)	—	○●	—	○●			
Clini5	Callegari (Italy)	○	○	○	—	○	—	○
CR3000	Callegari (Italy)	○	○	○	—	○	—	○
InnovaStar®	Diasys (Germany)	—	●	○	—	●	—	
HealthCube	HealthCubed (India)	○	○	—	—	○	—	e
Aina	Jana Care (USA)	○	○	○	—	○	e	
MS-S600	Medical System Biotech. (China)	●	●	—	●	●	—	e
Pointcare M3i	MNCHIP (China)	●	●	—	●	●	—	—
Allegro®	Nova Biomedical (USA)	○	○▲	○	○▲	○	e	
Swasthya Sahayak (Pro) [d]	Public Health Foundation India	○e	○	—	○e	—	—	
cobas b 101 system	Roche Diagnostics (Switzerland)	○	—	○	—	CRP		
Reflotron® Plus system	Roche Diagnostics (Switzerland)	○	○	—	○	○		
Reflotron® Sprint system	Roche Diagnostics (Switzerland)	○	○	—	○	○		
DCA Vantage® Analyzer	Siemens (Germany)	—	—	○	ACR	—		
Skyla™ HB1 POC Analyzer	Skyla Corporation (Taiwan)	●	●	—	●	●		
Skyla Hi Analyzer	Skyla Corporation (Taiwan)	○	●	○	e	e		
SimplexTAS 101	Tascom (Korea)	○	○	○	○	○	f	f

a. does not always apply to all parameters; Stringent regulatory authorities: http://www.stoptb.org/assets/documents/gdf/drugsupply/List_of_Countries_SRA.pdf; only FDA and CE-IVD are listed as information on other SRA registration was incomplete;
b. can be any or all of the following: cholesterol, triglycerides, LDL, HDL; **c.** if nothing is specified, the device has several other parameters; **d.** with or without CLIA-waiver; **e.** in progress or in development; **f.** no information available;

○ individually measured parameter (including lipid panels);
● as part of a panel of two or more parameters;
▲ on a connected companion device

available — not available

TECHNOLOGY LANDSCAPE

PRODUCT NAME	Piccolo Xpress®	Alere Afinion™ AS100 Analyzer	Afinion™ 2 Analyzer
Manufacturer	Abbott Laboratories (IL, USA)	Abbott Laboratories (IL, USA)	Abbott Laboratories (IL, USA)
Website	www.abbott.com	www.abbott.com/poct	www.abbott.com/poct
Chemistry/Methodology	Enzymatic chemistries according to targets	Different chemical and mechanical assay methods combined with advanced, computerized processing and measuring technology	Different chemical and mechanical assay methods combined with advanced, computerized processing and measuring technology
User	Primary care, urgent care, long-term care, community oncology, hospitals, government and military	Physician offices, clinics, community health centers, long term care, stationary screening, emergency rooms and hospital outpatient clinics	Physician offices, clinics, community health centers, long term care, stationary screening, emergency rooms and hospital outpatient clinics
Distinguishing features according to the manufacturer	Comprehensive Metabolic Plan is the only CLIA waived CMP in the US 		
TEST MENU			
Cardiometabolic Menu	Lipid Panel; Lipid Panel Plus (incl. glucose, liver function) Basic Metabolic Panel (incl. glucose, creatinine) Comprehensive Metabolic Panel (incl. glucose, creatinine, liver function)	HbA1c HbA1c Dx Lipid panel Albumin/Creatinine Ratio (ACR)	HbA1c HbA1c Dx Lipid panel Albumin/Creatinine Ratio (ACR)
Other menu	Liver Panel Plus; Renal Function Panel; Kidney Check; Electrolyte Panel; Further panels available	CRP	CRP
Reagent storage conditions	Room temperature unopened for 48 hours Store at 2–8°C	HbA1c: 24 months refrigerated 90 days 15–25°C Lipid panel: 12 months refrigerated 14 days 15–25°C ACR: 9 months refrigerated 3 days 15–25°C CRP: 12 months refrigerated 4 weeks 15–25°C	HbA1c: 24 months refrigerated 90 days 15–25°C Lipid panel: 12 months refrigerated 14 days 15–25°C ACR: 9 months refrigerated 3 days 15–25°C CRP: 12 months refrigerated 4 weeks 15–25°C
Reagent shelf-life	10–11 months refrigerated	See above	See above
Waste management/disposal	Standard blood and biological material disposal	Standard blood and biological material disposal	Standard blood and biological material disposal
REGULATORY APPROVAL			
Regulatory status	CE-IVD FDA	FDA/CLIA-waived; HbA1c FDA/Moderate complexity; ACR, HbA1c Dx CE-IVD: HbA1c, Lipid Panel, ACR, CRP	FDA/CLIA-waived;HbA1c FDA/Moderate complexity; ACR, HbA1c Dx CE-IVD: HbA1c, Lipid Panel, ACR, CRP
ORGANISATIONAL CAPABILITIES			
Footprint in LMICs	Distributors in Asia, Africa and Latin America	Available in US, APAC, Europe, Middle East, Africa and Latin America	Available in US, APAC, Europe, Middle East, Africa and Latin America
WORKFLOW FEATURES			
Throughput	One panel at a time	One at a time	One at a time
Run time	12 minutes	3–8 minutes (assay dependent)	3–7 minutes (assay dependent)
Sample types	Whole blood, plasma, serum	Whole blood, plasma, serum, urine	Whole blood, plasma, serum, urine
Min.-max. sample volume	100 µL	1.5–15 µL	1.5–15 µL
Sample preparation	3 steps	3 steps	3 steps
Reagent presentation	Single use disc rotor	Cartridge	Cartridge
No. of simultaneous tests	One rotor at a time. All rotors include test panels e.g. basic metabolic panel, Comprehensive Metabolic Panel	One	One
SOFTWARE CAPABILITIES			
Barcoded reagents	Yes	Yes	Yes
Sample barcode-reading capability	Yes	Optional bar code reader and printer via USB connection	Optional bar code reader and printer via USB connection
Autocalibration	Yes	Factory calibrated	Factory calibrated
Self-diagnose malfunctions	Yes	Yes	Yes
LIS/EHR system interfaced	Yes	Alere Afinion Data Connectivity Converter (ADCC)	Yes
Bidirectional capability	Yes	Yes	Yes
Memory	Up to 5,000 patient records	500 patient results; 500 QC results; 1,000 operator IDs	500 patient results; 500 QC results; 1,000 operator IDs
Data protection	Operators have passcodes Data can only be extracted with proprietary software	Operator lock-out configuration possible	Operator lock-out configuration possible
PHYSICAL FEATURES			
Dimensions (H x W x D)	32.4 cm x 15.2 cm x 20.3 cm	17 x 19 x 34 cm	20 x 18.6 x 32.8 cm
Weight fully loaded	5 kg	5 kg	3.4 kg
Power supply	UPS required. Powered by 100–240 V main supply or 15V DC (car battery)	Mains only	Mains only
Printer	Yes	Optional	Optional
Storage and transport conditions for the device	Discs need to be stored refrigerated at 2–8°C and used directly from the refrigerator	Temp: - 40–70°C Relative humidity: 10–93% at 40°C	Temp: - 40–70°C Relative humidity: 10–93% at 40°C
Operating conditions	Same as storage	15–32°C; 10–90%, non-condensing	15–32°C; 10–80%, non-condensing
SERVICE & SUPPORT			
Remote servicing possible	No	No	No
Training included	Provided by the supplier: Little training required to operate. Training provided on managing lab results, record keeping and good laboratory practices via live webcam or live on site. 26 tests are CLIA waived – no training required	Training provided by tech consultants/applications specialists/sales reps/distributors (depending on market) Follow instructions (product has a step-by-step quick reference guide). Training video for all platforms and tests are available on the website	Training provided by tech consultants/applications specialists/sales reps/distributors (depending on market) Follow instructions (product has a step-by-step quick reference guide). Training video for all platforms and tests are available on the website
Time needed for training	Not specified	~ 45 minutes	~ 45 minutes

PRODUCT NAME	Cholestech LDX™ Analyzer	i-STAT	Clini5
Manufacturer	Abbott Laboratories (IL, USA)	Abbott Laboratories (IL, USA)	Callegari SRL (Italy)
Website	www.alere.com	www.abbott.com	www.callegari1930.com
Chemistry/Methodology	Photospectrometry		Liquid Chemical – Photometric absorbance
User	Physician, paediatrician, and cardiologist offices, hospitals and wellness programs	Clinical and community-based settings	Healthcare operators
Distinguishing features according to the manufacturer	Full lipid panel and glucose from a small fingerstick in 5 minutes, eliminating call backs and reschedules, resulting in improved office efficiencies 	Hand-held 	Single tests; liquid system for clinical chemistry screening 
TEST MENU			
Cardiometabolic Menu	Lipid profile Lipid profile and glucose Total cholesterol Total cholesterol and glucose	Glucose Creatinine CHEM8+ panel: Glu, Crea, BUN/Urea, Hct, Hgb, Na, K, CL, TCO2, Anion Gap (cal.), iCa,	Total cholesterol HDL, LDL (calculated) Triglycerides Glucose HbA1c
Other menu	None	Lactate panel Different panels for: chemistry and electrolytes, haematology, coagulation, endocrinology, blood gases, cardiac markers	Hematic tests (RBC, Hb, Hct), Oxidative stress (FORT, FORD), Hepatic tests (ALT, AST)
Reagent storage conditions	2–8°C, or room temperature	2–8°C	2–30°C
Reagent shelf-life	Up to 12 months at 2–8°C or 30 days at room temperature (up to 30°C)		6–18 months
Waste management/disposal	Standard blood and biological material disposal	Biological hazard waste	Standard blood and biological material disposal
REGULATORY APPROVAL			
Regulatory status	CE-IVD FDA CLIA waived	CE-IVD FDA/CLIA-waived	CE-IVD
ORGANISATIONAL CAPABILITIES			
Footprint in LMICs	Global operations in > 160 countries	Worldwide operations	Indonesia, Malaysia and others
WORKFLOW FEATURES			
Throughput	One at a time (11 tests per hour max)	One cartridge at a time	Five tests at a time
Run time	5 minutes	2 min (CHEM8+)	2–7 min
Sample types	Fingerstick or venous whole blood samples	Whole blood	Whole blood, plasma
Min.-max. sample volume	40 µL	65–95 µl	5–50 µl
Sample preparation	2 steps (prick finger and capillary tube fill)	3 steps	6 steps
Reagent presentation	Cassette	Cartridges	Single-dose reagents, reagent vials
No. of simultaneous tests	One cassette at a time	1 (panel)	5
SOFTWARE CAPABILITIES			
Barcoded reagents	Yes	Yes	No
Sample barcode-reading capability	No	Yes	No
Autocalibration	Yes	Yes	Optical signal auto configuration
Self-diagnose malfunctions	Yes	Yes	Autotest – Error Messages
LIS/EHR system interfaced	No	Yes	No
Bidirectional capability	Yes	Yes	Yes
Memory	Last result	Yes	3 GB
Data protection		Lockout feature	Yes
PHYSICAL FEATURES			
Dimensions (H x W x D)	21 x 12 cm	7.24 x 7.68 x 23.48 cm	15.5 x 33 x 24 cm
Weight fully loaded	1 kg	0.65 kg	2.7 kg
Power supply	100–240V main power supply	Two (2) 9-volt disposable lithium, rechargeable batteries	12 V DC–3.5 A
Printer	Optional	Thermal printer	External thermal printer, Wi-Fi
Storage and transport conditions for the device	Temp: 20–31°C Humidity: 20% to 80%		Storage temp: 8–38°C, relative humidity: 95% Transport temp: -10°C, relative humidity: 95%
Operating conditions		16–30°C for i-STAT cartridge testing	Temp: 15–40°C
SERVICE & SUPPORT			
Remote servicing possible	Not required	Yes	Yes
Training included	Not required. CLIA waived. Training via online videos from website or local customer support		Yes
Time needed for training			3 h

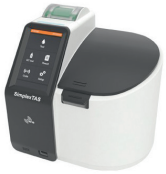
PRODUCT NAME	CR3000	InnovaStar®	HealthCube
Manufacturer	Callegari SRL (Italy)	DiaSys Diagnostics Systems (Germany)	HealthCubed (India)
Website	www.callegari1930.com	www.diasys-diagnostics.com	www.healthcubed.com
Chemistry/Methodology	Liquid Chemical – Photometric absorbance	Photometric, Turbidimetric	Device capable of measuring multiple parameters integrating electro-biochemistry, immunochemistry, and other methods
User	Healthcare operators	Healthcare operators	Basic level healthcare worker
Distinguishing features according to the manufacturer	Single tests; liquid system for clinical chemistry screening 	Fully automated system, measure up to four tests from one sample 	Results available on mobile phone app Includes ports for connecting blood pressure cuff, ECG cables, pulse oximeter probes & other parameters 
TEST MENU			
Cardiometabolic Menu	TOT Cholesterol, HDL Cholesterol, LDL Cholesterol, CHD (Coronary Heart Disease Risk), Triglycerides, Glucose, HbA1c	Glucose & Haemoglobin panel HbA1c	Glucose Cholesterol
Other menu	Hematic tests (RBC,Hb, Hct), Oxidative stress (FORT, FORD), Hepatic tests (ALT,AST)	CRP	Troponin I (Rapid card) D Dimer (Rapid card) Haemoglobin Uric acid Blood pressure, pulse oximeter, ECG module
Reagent storage conditions	2–30°C	2–8°C	In the shade. Room temperature
Reagent shelf-life	12–18 months	18 months	12–18 months
Waste management/disposal	Biological hazard waste	Biological hazard waste	Standard blood and biological material disposal
REGULATORY APPROVAL			
Regulatory status	CE-IVD	CE-IVD	Organization is ISO13485, Indian FDA Cleared (operate under a No-objection certificate), Tests validated. CE marking in progress
ORGANISATIONAL CAPABILITIES			
Footprint in LMICs	Indonesia, Malaysia and others	Global distributor network	Rolling out across several states in India, Kenya, Angola. To begin operation in Senegal
WORKFLOW FEATURES			
Throughput	Three tests at a time	One cartridge at a time	One patient at a time. Typical screening time ~ 4 to 5 min
Run time	2–7 min	6.5 min	Varying times, depends on the test. From 10 s to 45 seconds
Sample types	Whole blood - plasma	Whole blood	Capillary whole blood, urine
Min.-max. sample volume	5–50 µl	10 µl	Approx. 5 µL for electrochemistry tests and 50 µL for Rapid Card Tests
Sample preparation	6 steps	3 steps	Typically none
Reagent presentation	Single dose reagents, reagents vials	Cartridges	Tests strips and cards
No. of simultaneous tests	3	1	Ability to run 3 tests simultaneously in development
SOFTWARE CAPABILITIES			
Barcoded reagents	Yes	Yes	In development
Sample barcode-reading capability	Yes	Yes	Can read patient ID barcodes
Autocalibration	Optical signal auto configurations	No (pre-calibrated reagents)	Yes
Self-diagnose malfunctions	Autotest – Error Messages	Error messages	Yes
LIS/EHR system interfaced	No		Feature available
Bidirectional capability	Yes	Yes	
Memory	Yes	Yes	Depends on mobile device
Data protection	No		Encrypted databases and communication protocols
PHYSICAL FEATURES			
Dimensions (H x W x D)	7.4 x 25.5 x 24 cm	15 x 20 x 17 cm	25 x 20 x 65 cm
Weight fully loaded		4 kg	2.3 kg (Reduced to 1.6 kg)
Power supply	12 V DC ± 0,5V 3,5A	Mains supply	Operated through micro-USB power bank with a rechargeable lithium-ion battery
Printer	Thermal printer	Thermal printer	External. Connected through the mobile device
Storage and transport conditions for the device	Transport: 5–30°C/59–86°F (Rh 90% max.) Storage: 8–38°C/46.40–100.40°F (Rh 95% max.)		Storage at ambient room temperature.
Operating conditions			
SERVICE & SUPPORT			
Remote servicing possible	Yes	Yes	No
Training included	Yes		Yes
Time needed for training	3h		3–4 hours

FIND
Because diagnosis matters

PRODUCT NAME	Aina	MS-S600 (mWafer)	Pointcare M3i
Manufacturer	Jana Care, Inc. (USA)	NINGBO MEDICALSYSTEM BIOTECHNOLOGY CO.,LTD.	MNCHIP (China)
Website	www.janacare.com	http://www.nb-medicalsystem.com/	www.mnchip.com
Chemistry/Methodology	Dry enzymatic analysis Chemical affinity, immunoassay	Lyophilized chemistry reagent with microfluidic rotor mixer, colorimetric measurement with Beer-Lambert law	Microfluidics
User	Primary care or home use	Doctors or nurses in clinic / general practice / lab technicians, etc.	Primary healthcare facility
Distinguishing features according to the manufacturer	Includes a phone app that helps the patient track and manage their glucose and cholesterol, lifestyle factors (weight, food and exercise) 	Automatic centrifuge for whole blood and reagent mixture with microfluidic technology. Auto calibration by barcode with a built-in barcode reader. Easy operation and maintenance free. 	
TEST MENU			
Cardiometabolic Menu	Total cholesterol HDL, Triglycerides, LDL (calculated) Glucose HbA1c	General Chemistry: AST, ALT, ALB, TP, GGT, GLU, TBIL, AMY, TBA, BUN, UA, CR Panel including lipids: AST, LDH*, CK*, CK-MB*, HCY*, TG, TCH, HDL, LDL#, VLDL# (*parameters are coming soon, #parameters are obtained by algorithm calculation)	Glucose & lipid panel GLU & lipid & HCY panel General chemistry panel (incl. creatinine)
Other menu	Haemoglobin NT-pro-BNP	Liver Plus: AST, ALT, ALB, ALP, TP, GGT, GLU, ADA, TBA, TBIL, AMY Renal panel incl. CREA and further panels coming soon	Renal function panel Liver function panel Other panel combinations
Reagent storage conditions	2–8°C for HbA1c, room temperature for other tests	stored at 2–8°C with foil paper package	2–8°C
Reagent shelf-life	12–18 months depending on test	9 months. Must use the disc within 20 minutes of opening its pouch.	12 months
Waste management/disposal	Standard blood and biological material disposal	Standard blood and biological material disposal	Standard blood and biological material disposal
REGULATORY APPROVAL			
Regulatory status	CE-IVD, HSA (Singapore), Philippines FDA, Malaysia MDA, US FDA in progress	CE-IVD (in progress)	CE-IVD
ORGANISATIONAL CAPABILITIES			
Footprint in LMICs	South Asia, Southeast Asia, Kenya	Operate worldwide	Rwanda, Kenya, India, Philippines, Pakistan, Egypt, Algeria, Guyana, Colombia, Chile, Romania, Bulgaria, Guyana, Colombia, Chile etc. (over 60 countries)
WORKFLOW FEATURES			
Throughput	One at a time (handheld)	Four discs per hour (average 15mins per panel testing with multi-parameters)	One panel at a time with multiple parameters
Run time	3 seconds to 3 minutes, depending on the test	Within 13-15 mins to complete panel testing	8 min
Sample types	Capillary and venous whole blood	Lithium heparinized whole blood, Lithium heparinized plasma, Serum, pre-diluted sample	Whole blood, plasma, serum
Min.-max. sample volume	2–15 µl	Multi panel rotor: 140 µL/pcs Small segmental rotor: 40 µL/pcs	100 µl
Sample preparation	3 steps (HbA1c) Sample-to-answer (glucose, lipids and haemoglobin)	1 step	3 steps
Reagent presentation	Dry strip, Liquid reagent	Lyophilized chemistry reagent	Reagent discs
No. of simultaneous tests	3	1	One disc at a time
SOFTWARE CAPABILITIES			
Barcoded reagents	Yes	Yes	Yes
Sample barcode-reading capability	Yes	Yes	In development
Autocalibration	Yes	Yes	Yes
Self-diagnose malfunctions	Yes	Yes	Yes
LIS/EHR system interfaced	Via mobile phone	Yes	Yes
Bidirectional capability	Via mobile phone	Yes	3G, Wi-Fi, USB
Memory	Unlimited (cloud)	100,000 sample data	50'000 records
Data protection	Yes	Yes	Yes
PHYSICAL FEATURES			
Dimensions (H x W x D)	Small strip reader attached to mobile phone 8 x 3.7 x 1.6 cm	27 x 26.3 x 20.5 cm	17.5 x 12.5 x 21 cm
Weight fully loaded	0.032 kg with battery	4.9 kg	2.5 kg
Power supply	AAA battery	110–240 volts AC, 50–60 Hz	AC 100–240 V
Printer	Wireless printer	Wireless Bluetooth printer	Optional external printer
Storage and transport conditions for the device	Tested up to 50°C	The packaged product shall be stored at 0–40°C, with relative humidity not exceeding 85%, free of corrosive gases and in a well-ventilated environment. Prevent severe impact, water and exposure during the transportation.	Temperature: 10–30°C Humidity: 40–85%
Operating conditions	HbA1c: 18–40°C; Glucose: 10–35°C; Lipids: 10–40°C; Haemoglobin: 15–30°C	Temp: 15–30°C / Humidity: 30–70%	Same as storage
SERVICE & SUPPORT			
Remote servicing possible	Yes	Yes	Online after-sales service
Training included	Yes	Setting up the analyser, outline of measurement, preparation for measurement, running the test, cautions while operating, configuring the settings, quality control	Yes
Time needed for training	45 minutes to 1.5 hours	3–5 hours	1–2 hours

PRODUCT NAME	Allegro®	Swasthya Sahayak (Pro)	cobas b 101 system
Manufacturer	Nova Biomedical	Public Health foundation India	Roche Diagnostics (Switzerland)
Website	www.novabiomedical.com	http://www.swasthyasahayak.com/swasthya_sahayak/	www.diagnostics.roche.com
Chemistry/Methodology	Enzymatic & immunoassay	Electrochemical biosensor technology	Dry chemistry: Lipid panel is enzymatic chemistry HbA1c & CRP are immunoassays (agglutination)
User	Endocrinologist, primary care physician	Accredited health workers involved in reproductive, maternal and child health care (RMNCH) and non-communicable disease (NCD) screening	Suitable for primary care and hospital point of care settings
Distinguishing features according to the manufacturer	Has 2 bays for simultaneous testing Companion hand-held instrument that transmits data to the main instrument to be combined with all results 	Key feature of the device is that it helps a frontline health worker to deliver all the required diagnostics and basic decision support required for RMNCH and NCD services both at a remote health facility or in a domestic settings 	Capillary whole blood sample application without transfer device directly onto the reagent discs. Reagent disc storage under room temperature 
TEST MENU			
Cardiometabolic Menu	From fingerstick: HbA1c, Lipid panel, Blood glucose (companion instrument), Blood creatinine (companion instrument) From urine: creatinine	Glucose, Haemoglobin, Urine albumin/creatinine ratio *Pro version (in development) to include lipid profile and renal function	HbA1c Lipid profile: Cholesterol, Triglycerides HDL-cholesterol
Other menu	From fingerstick: PT/INR, Hb/Hct, Uric acid From urine: Urine albumin, Albumin/creatinine ratio	Proteinuria, Glycosuria, Troponin Maternal and child health, Communicable disease Acute care, Pulse oximeter, Blood pressure	CRP
Reagent storage conditions		6–42°C	2–30°C
Reagent shelf-life	2 years for test strips	2 years	CRP: 16 months; Lipid: 16 months; HbA1c: 22 months
Waste management/disposal	Standard blood and biological material disposal	Standard blood and biological material disposal	Standard blood and biological material disposal
REGULATORY APPROVAL			
Regulatory status	CE-IVD FDA pending	CE-IVD	CE-IVD, Japan, Canada USA: 510k for system and HbA1c only
ORGANISATIONAL CAPABILITIES			
Footprint in LMICs	100 countries and Asia. Distributors in Africa, LATAM	HQ in India	Operate worldwide. Strong support in LMICs
WORKFLOW FEATURES			
Throughput	Two at a time	One at a time	One at a time
Run time	3–9.5 min, assay dependent Companion handheld meter with 6–40 seconds	2 minutes	4–6 minutes, assay dependent
Sample types	Capillary whole blood Venous & arterial whole blood if available Urine	Capillary whole blood Urine	Capillary whole blood or serum, venous whole blood or plasma (Heparin or EDTA), depending on assay
Min.-max. sample volume	1.2–1.6 µL for test strips 1.5–5 µl, assay dependent	1–2 µL	2–19 µL, depending on assay
Sample preparation	5 steps	2 steps	3 steps
Reagent presentation	Cartridges & test strips for companion handheld	Single test cartridges for some tests and multi-test cassettes/cartridges for lipid profile and renal functions	Disc cartridge
No. of simultaneous tests	2	1	1
SOFTWARE CAPABILITIES			
Barcoded reagents	Yes	Currently not available	Yes
Sample barcode-reading capability	N/A		Yes
Autocalibration	Yes		Yes (manufacturer calibrated)
Self-diagnose malfunctions	Yes	Yes	Yes
LIS/EHR system interfaced	Yes	Will be interfaced	Yes
Bidirectional capability	Yes		Yes
Memory	Virtually unlimited. Stores and presents trend data for patients over the last 9 visits. Companion meter storage: Patient results: 1,000; QC tests: 200; No. of users: 4,000	Can store 1,000 records	5,000 patient results, 500 QC results, 50 operator IDs
Data protection		Yes SSL	Yes. Operator ID entry and Password entry available. Auto–log off available.
PHYSICAL FEATURES			
Dimensions (H x W x D)	35.6 x 20.3 x 38.1 cm	23 x 18 x 5 cm	13.5 x 18.4 x 23.4 mm
Weight fully loaded	10.43 kg	0.75 kg	2.0 kg (without power adapter)
Power supply	Mains any voltage	AC 220 Watt	Delivered with Instrument. Suitable for (115 / 230 Volt; 50 / 60 Hz).
Printer	Yes, standard built in	Yes	Citizen systems: CT-S281
Storage and transport conditions for the device	Room temperature	Provided in a backpack bag No specific condition required	Temp: -25–60°C Relative humidity: 10–90% (no condensation)
Operating conditions	As storage conditions	Temp: 10–40°C, altitude tested	Temp: 15–32°C Relative humidity: 10–85% (no condensation) Maximum altitude for operation: 3000 m
SERVICE & SUPPORT			
Remote servicing possible	No	Field servicing possible	No
Training included	Yes	Yes	Not required. Training free system. Designed to get CLIA waiver approval
Time needed for training	1 hour	2 days	N/A

PRODUCT NAME	Reflotron® Plus system	Reflotron® Sprint system	DCA Vantage® Analyzer
Manufacturer	Roche Diagnostics (Switzerland)	Roche Diagnostics (Switzerland)	Siemens Healthineers (Germany)
Website	www.diagnostics.roche.com	www.diagnostics.roche.com	www.siemens-healthineers.com
Chemistry/Methodology	Dry chemistry: Enzymatic reaction producing a dye, the intensity of which is proportional to the concentration of the target molecule	Dry chemistry: Enzymatic reaction producing a dye, the intensity of which is proportional to the concentration of the target molecule	
User	Suitable for primary care settings, as a back-up system in hospitals and private labs, at screening sites and for health check-up	Suitable for primary care settings, as a back-up system in hospitals and private labs, at screening sites and for health check-up	Doctor's office Decentralized settings
Distinguishing features according to the manufacturer			RAPIDComm® Data Management System allows coordinators to oversee and trouble shoot multiple connected analyzers in real time 
TEST MENU			
Cardiometabolic Menu	Glucose Cholesterol HDL Cholesterol Triglycerides Creatinine	Glucose Cholesterol HDL Cholesterol Triglycerides Creatinine	HbA1c Albumin, Creatinine and Albumin/Creatinine ratio (urine test)
Other menu	Alkaline phosphatase, Amylase, Bilirubin, CK, GGT, GOT (AST),GPT (ALT), K (Potassium), Pancreatic amylase, Urea, Uric acid	Alkaline phosphatase, Amylase, Bilirubin, CK, GGT, GOT (AST),GPT (ALT), K (Potassium), Pancreatic amylase, Urea, Uric acid	None
Reagent storage conditions	2–8°C or 2–25/30°C depending on the test	2–8°C or 2–25/30°C depending on the test	Room temperature or refrigeration
Reagent shelf-life	10–18 months	10–18 months	Room Temp: 90 days Refrigerated: until expiry date
Waste management/disposal	Standard blood and biological material disposal	Standard blood and biological material disposal	Standard blood and biological material disposal
REGULATORY APPROVAL			
Regulatory status	CE-IVD China FDA Japan	CE-IVD China FDA Japan	CE-IVD FDA CLIA waived
ORGANISATIONAL CAPABILITIES			
Footprint in LMICs	Operate worldwide Strong support in LMICs	Operate worldwide Strong support in LMICs	Siemens Healthineers is a large global company with operations in LMICs
WORKFLOW FEATURES			
Throughput	Up to 25 tests per hour	Up to 60 tests per hour	One at a time
Run time	2–3 minutes depending on test	2–3 minutes depending on test	6 minutes
Sample types	Whole blood (capillary and venous) plasma or serum	Whole blood (capillary and venous) plasma or serum	Fingerstick whole blood (HbA1c) Urine (Microalbumin)
Min.-max. sample volume	30 µL	30 µL	1 µl
Sample preparation	3 steps	3 steps	3 steps
Reagent presentation	Dry test strip	Dry test strip	Reagent is in cassette
No. of simultaneous tests	None	None	One cassette at a time
SOFTWARE CAPABILITIES			
Barcoded reagents	Lot specific magnetic barcodes in strips	Lot specific magnetic barcodes in strips	Yes
Sample barcode-reading capability	Yes	Yes	Yes
Autocalibration	Factory calibrated	Factory calibrated	Yes
Self-diagnose malfunctions	No	No	Yes
LIS/EHR system interfaced	No	No	Serial or Ethernet connection
Bidirectional capability	No	No	POCT1-A2 from LIS/HIS, RapidComm, or third party DMS
Memory	None	Up to 500 results with date and time	4000 patient/control records; 1000 operators
Data protection	N/A		
PHYSICAL FEATURES			
Dimensions (H x W x D)	30 x 35 x 21 cm	26 x 55 x 35 cm (display folded down) 42 x 55 x 35 cm (display folded upright)	23 x 28 x 27 cm
Weight fully loaded	5.3 kg	13 kg	4 kg
Power supply	Mains: 115–230 V AC (+/-22%) Frequency: 47 Hz to 63 Hz Car battery optional: 10–30 V DC	Mains: 115–230 V AC	100–240 VAC 50/60 Hz
Printer	Yes	Yes	On-Board
Storage and transport conditions for the device	Temp: -20–55°C when packed Relative humidity: 5–95% when packed	Temp: -20–70°C when packed Relative humidity: 20–90% when packed	15–32°C
Operating conditions	Temp: 15–34°C, relative humidity up to 95%	Temp: 15–34°C, relative humidity up to 95%	
SERVICE & SUPPORT			
Remote servicing possible	No	No	No
Training included		Yes. Display messages guide the user Over 50 function controls ensure the working safety of the instrument	Yes
Time needed for training			60 minutes

PRODUCT NAME	Skyla™ HB1 POC Analyzer	Skyla Hi Analyzer	SimplexTAS 101
Manufacturer	Skyla Corporation (Taiwan)	Skyla Corporation (Taiwan)	Tascom (Korea)
Website	www.skyla.com	www.skyla.com	www.tascom.org
Chemistry/Methodology	Combined biochemistry and electrolyte functions; Colorimetric method	Combined turbidimetry, colorimetry and ELISA	Immuno-chemistry
User	Portable device intended for use in smaller labs	Portable device intended for use in smaller labs	Primary healthcare settings
Distinguishing features according to the manufacturer	Results available on mobile phone app 		
TEST MENU			
Cardiometabolic Menu	Lipid panel + glucose Metabolic panel (incl. glucose and creatinine)	HbA1c Lipid panel Lipid Plus panel (incl. glucose) Creatinine (in development)	Glucose HbA1c Lipids (TC, TG, HDL) Creatinine
Other menu	General biochemistry panel Basic biochemistry panel Liver panel Further panels available	CRP Further tests in development (renal function, reproductive health, thrombosis, inflammation, bone metabolism)	CRP Haemoglobin ALB (U), CRE (U), ACR, AST, ALT, GGT, ß-HB, BUN Further tests in development (e.g. troponin, BNP, D-dimer, albumin)
Reagent storage conditions	2–8°C	2–8°C (Some items at room temperature)	2–8°C
Reagent shelf-life	14 months	12–16 months	12 months
Waste management/disposal	Standard blood and biological material disposal	Standard blood and biological material disposal	Standard blood and biological material disposal
REGULATORY APPROVAL			
Regulatory status	CE-IVD, CFDA, TFDA, FDA	CE-IVD, CFDA, TFDA, FDA	No information available
ORGANISATIONAL CAPABILITIES			
Footprint in LMICs	Registered in China and Taiwan	Registered in China and Taiwan	
WORKFLOW FEATURES			
Throughput	One at a time	Two tests per run	Four samples per run
Run time	13.5 minutes	6–13 minutes depending on the assay	10 min
Sample types	Whole blood, serum, plasma	Fingerstick or venous blood	Whole blood, plasma or urine
Min.-max. sample volume	200 µL	0.8–30 µL depending on assay	4–20 µl
Sample preparation	3 steps	3 steps	
Reagent presentation	Reagent discs	Reagent cartridges	Reagent cartridges
No. of simultaneous tests	One disc at a time	2	4
SOFTWARE CAPABILITIES			
Barcoded reagents	Yes	Yes	Yes, RFID tag
Sample barcode-reading capability	Yes	Yes	
Autocalibration	Yes	Yes	
Self-diagnose malfunctions	Yes	Yes	
LIS/EHR system interfaced	Yes	Yes	Yes
Bidirectional capability		Yes	
Memory	50,000 results	50,000 results	2,000 patient results 200 control results 100 IQC results
Data protection			
PHYSICAL FEATURES			
Dimensions (H x W x D)	30.0 x 23.3 x 28.5 cm	27 x 18.8 x 8.3 cm	26.2 x 26.5 x 21.7 cm
Weight fully loaded	5.5 kg	1.7 kg	3.4 kg
Power supply	Mains supply	Mains supply	100-240 VAC input
Printer	Built in thermal printer or external USB printer (PCL3GUI)	Thermal printer and Skyla Data Manager PC Software supported	
Storage and transport conditions for the device	Temperature: 10–32°C Humidity: 5–90%	Temperature: 10–32°C Humidity: < 95% (non-condensing)	Temperature: 4–40°C (operating temperature 18–32°C) Humidity: 10–70 % (non-condensing)
Operating conditions			
SERVICE & SUPPORT			
Remote servicing possible	No	Yes	
Training included	Yes	Yes	
Time needed for training			

NB: Images not to scale; empty fields mean no information was available

BIOLOGY AND CLINICAL UTILITY OF CARDIOMETABOLIC POC DIAGNOSTICS

BLOOD LIPID PROFILE TESTING

Lipids are essential for the health and survival of both animals and humans and are obtained via food intake or synthesized in the liver. Lipids are ingested as cholesterol or triglycerides and freely circulate in the blood as low- or high-density lipoproteins (LDL and HDL). In healthy individuals, there are relatively few LDL particles in the blood. The presence of arterial plaques is associated with high numbers of LDL lipoproteins, whereas high numbers of HDL lipoproteins are typically associated with lower levels of arterial plaque and better health outcomes.

Epidemiological studies [17, 18] have shown the association between high serum cholesterol and increased cardiovascular disease risk; randomized control trials (RCTs) have shown that lowering serum cholesterol reduces this risk [19]. As a rough guide, the American College of Cardiology/American Heart Association (ACC/AHA) 2018 guidelines [20] state that a 1% reduction in LDL cholesterol levels gives an approximate 1% reduction in risk of arteriosclerotic CVD.

According to the International Atherosclerosis Society (IAS), the prime focus for preventing cardiovascular disease should be on lowering serum LDL and keeping it low throughout life [21].

The standard method as per the ACC/AHA guidelines for measuring serum LDL is to measure total cholesterol, triglycerides and HDL, and then calculate LDL using the Friedewald equation:

$$\text{LDL} = \text{total cholesterol} - (\text{triglycerides}/5) - \text{HDL}$$

Targets for LDL levels at low, medium and high lifetime risk for CVD vary around the world and are driven by population-based factors such as genetics, the prevalence of risk factors in specific populations and the cost and practicality of preventative lipid lowering therapy.

The accuracy of point-of-care tests for lipid profiles and cholesterol measurements has been assessed by several studies [22-24] but, to our knowledge, no systematic reviews or meta-analyses have been published and none of the guidelines reviewed for this document contained recommendations regarding the use of POC cholesterol tests. One report by the Canadian Agency for Drugs and Technologies in Health [25] provided a review of studies done to date comparing the performance of POC cholesterol tests with their laboratory-based counterparts. These included one large multicentre RCT, six non-randomized studies and six evidence-based guidelines. The RCT was a large multicentre Australian study which randomized nearly 5,000 patients with diabetes or hyperlipidaemia or who were receiving anticoagulant therapy, and compared blood and urine POC testing with laboratory testing over a period of 17 months. The RCT authors concluded that POC testing was no worse than conventional laboratory testing for measurement of total cholesterol and triglycerides. The six non-randomized studies compared POC testing with laboratory testing for lipid profiles. In general, these studies found that POC testing “is an accurate and useful alternative to laboratory testing for CVD screening purposes based on cholesterol levels”. The report, therefore, concluded that POC cholesterol testing for screening of asymptomatic adults offers several advantages over conventional laboratory testing, including testing of small blood samples, short turnaround times, no specimen transport, and no requirement for repeat clinic visits to obtain results.

In 2017, the World Heart Federation produced a Cholesterol Roadmap [26] aimed at identifying the roadblocks to cholesterol management in LMICs, recommending ways to overcome them. The report concluded that, although effective strategies for detection, treatment and management of elevated cholesterol and familial hypercholesterolaemia are known, several barriers to their implementation in low-resource settings exist. These include a lack of laboratory services and trained professionals for cholesterol management, unaffordability of statins, and low awareness of the importance of compliance to treatment regimens, amongst both healthcare providers and the public at large. In this environment, access to POC cholesterol testing can be effective, provided that broader healthcare programmes are in place to create awareness about CVD risk, trained professionals are available to diagnose and treat patients with elevated cholesterol, and lipid-lowering drugs are affordable.

BLOOD GLUCOSE AND HBA1C TESTING

Diabetes mellitus is a group of disorders characterized by hyperglycaemia resulting from a lack of insulin production or impaired insulin action, or both. Insulin is released when blood glucose levels rise in order to facilitate cellular uptake of blood glucose. The most common types of diabetes are type 1 and type 2. In type 1 diabetes, the cells in the pancreas that produce insulin are destroyed (most commonly in an immune-mediated process) and in type 2 diabetes, the body's cells have a reduced ability to respond correctly to the presence of insulin in the blood, combined with deficient insulin production. Diabetes is diagnosed by measuring plasma glucose levels and/or HbA1c levels, together with clinical signs and symptoms [27]. Direct blood glucose measurements provide short-term information on an individual's current glucose levels and are used to diagnose diabetes, monitor glycaemic control and adjust medication dosage. WHO guidelines for diagnosis of diabetes in resource-limited settings include the use of capillary glucose testing if only POC, and not laboratory testing, is available [6]. Urine glucose levels can be used as a test for undiagnosed diabetes in these settings even though its usefulness is limited by its low sensitivity (21–64%). Nevertheless, its specificity is high (>98%), so it is recommended if no other procedures are available and if symptoms are present.

Monitoring of glycaemic control has been performed for decades using single-parameter glucose meters, both in hospital POC settings and for home monitoring. These glucose meters are not listed in detail in the landscape tables, as the focus is on multi-parameter platforms.

Another marker for assessing blood glucose levels is HbA1c. HbA1c offers an indication of the average glucose level over the most recent three months and can be used to diagnose diabetes mellitus and is the gold standard for monitoring long-term blood glucose control in diabetes patients.

The biology of HbA1c and its utility as a marker of blood glucose control is well understood. Haemoglobin becomes covalently bound to glucose when blood glucose levels rise; once bound, a glycated haemoglobin molecule remains bound for the life of the red blood cell. As red blood cells have a life of 3–4 months, the level of glycated haemoglobin is a reflection of long-term glucose control.

Most guidelines recommend the diagnostic criterion proposed by WHO for diagnosis of diabetes using HbA1c levels in the blood [15]. For monitoring of glycaemic control, the IDF specifically recommends HbA1c testing should be performed using a method that is NGSP-certified (National Glycohemoglobin Standardization Program) and standardized to the Diabetes Control and Complications Trial [28] and the United Kingdom Prospective Diabetes Study [29]. Both have established direct associations between HbA1c levels and outcome risks in people with diabetes.

Several studies have shown a significant reduction in microvascular complications of diabetes and cardiovascular disease with a moderate reduction in HbA1c levels [30, 31]. Although these results have not been replicated in all studies, it is generally accepted that management of HbA1c levels in diabetic patients prevents the progression of diabetes and may delay the onset of both microvascular complications and cardiovascular disease.

The limitations of HbA1c tests relate to the performance of the test in patients with reduced or increased red blood cell counts [32]. Non-glycaemic factors that may falsely lower HbA1c measurement are acute blood loss or recent blood donation, chronic liver disease, haemolytic anaemias, anti-retroviral therapy for HIV infection, pregnancy and vitamin E & C levels. Conditions that may falsely elevate HbA1c levels are aplastic anaemias, hyperbilirubinaemia, hypertriglyceridaemia, iron deficiency anaemias, renal failure and splenectomy. Some conditions may either lower or elevate HbA1c, and these would include malnutrition and haemoglobinopathies or haemoglobin variants which may be present in certain ethnic groups.

The value of HbA1c POC testing is greater in hard to reach places. In a 2018 review on access to HbA1c testing in rural Africa, Park et al. [33] laid out the challenges of managing diabetes in remote and resource limited communities. Many diabetes patients in rural Sub-Saharan Africa do not own a blood glucose monitoring device, which requires them to routinely travel to public health clinics, district hospitals or health centres. While a fasting blood glucose test performed during these visits may provide some insights to physicians, this does not provide a longer-term average read on glycaemic control. This leaves clinicians relying on a single, potentially unrepresentative glucose reading from which to make treatment decisions. This situation led these and other authors to strongly advocate for access to POC HbA1c tests for monitoring of glycaemic control in Sub-Saharan Africa [34-38].

SERUM CREATININE TESTING

Creatinine is a by-product of the creatine phosphorylation reaction, catalysed by creatine kinase in organs, muscles and brain. Creatine phosphate is a high energy compound that acts as an energy reservoir in the body. Creatinine produced from the formation of creatine phosphate is released into the blood and excreted by the kidneys, primarily by glomerular filtration as well as by proximal tubular secretion. If the kidney is not functioning as it should, serum creatinine levels will rise. Serum creatinine levels are therefore a useful indicator of renal function and are commonly used to assess it.

Kidney malfunction may be a component of the pathophysiology of hypertension and heart failure, and kidney disease is a common complication of both hypertension/heart failure and diabetes.

Serum creatinine is an indirect measure of kidney function and correlates approximately with the rate at which the kidneys filter the blood (called glomerular filtration rate, GFR). Serum creatinine levels can be used to calculate the estimated glomerular filtration rate (eGFR) or be used as an independent marker of kidney function. Serum creatinine levels vary with age and across different ethnic populations and must be interpreted with individual patient characteristics in mind [39].

Chronic kidney disease is defined in the KDIGO (Kidney Disease Improving Global Outcomes) guidelines [40] as “abnormalities of kidney structure or function, present for >3 months, with implications for health”. These abnormalities include either one or more of the following: albuminuria, urine sediment abnormalities, electrolyte or other abnormalities due to tubular disorders, abnormal histology, structural abnormalities detected by imaging, and a history of kidney transplant, or decreased GFR [41].

Expert panels have found insufficient evidence to support screening for CKD in the general population and the KDIGO guidelines target testing for CKD in high-risk populations only, i.e. patients with diabetes and/or hypertension.

In LMICs, access to nephrology specialists is very limited, and may be further compounded by large distances between patients’ homes and their nearest healthcare facility. POC testing for serum creatinine could greatly assist in the care of these patients and improve the detection and management of their condition [42]. In a 2014 review of the performance of ten POC creatinine testing devices, performed by the UK National Institute for Health Research, the majority of studies found creatinine POC devices to be rapid and reliable alternatives to laboratory testing [43].

ACKNOWLEDGEMENTS

We would like to thank the representatives of the various manufacturers for the time they spent reviewing the information on each device.

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ABOUT FIND

FIND is a global non-profit organization that drives innovation in the development and delivery of diagnostics to combat major diseases affecting the world's poorest populations. Our work bridges R&D to access, overcoming scientific barriers to technology development; generating evidence for regulators and policy-makers; addressing market failures; and enabling accelerated uptake and access to diagnostics in low- and middle-income countries (LMICs). Since 2003, we have been instrumental in the development of 24 new diagnostic tools. Over 50 million FIND-supported products have been provided to 150 LMICs since the start of 2015. A WHO Collaborating Centre, we work with more than 200 academic, industry, governmental, and civil society partners worldwide, on over 70 active projects that cross six priority disease areas. FIND is committed to a future in which diagnostics underpin treatment decisions and provide the foundation for disease surveillance, control, and prevention.

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