# Cardiometabolic medicine – the US perspective on a new subspecialty

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**The high prevalence of cardiovascular disease and worldwide diabetes epidemic has created an ever-increasing burden on the healthcare system. This calls for the creation of a new medicine subspecialty: cardiometabolic medicine. Using information from review articles listed on PubMed and professional society guidelines, the authors advocate for a cardiometabolic medicine specialization training program. The curriculum would integrate relevant knowledge and skills of cardiology and endocrinology as well as content of other disciplines essential to the optimal care of cardiometabolic patients, such as epidemiology, biostatistics, behavioral science and psychology. Cardiometabolic medicine should be seen as an opportunity for life-long learning, with core concepts introduced in medical school and continuing through CME courses for practicing physicians. To improve care for complex patients with multiple co-morbidities, a paradigm shift must occur, transforming siloed education, and treatment and training to interdisciplinary and collaborative work.** *Cardiovasc Endocrinol Metab* **9: 70–80** 

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## Introduction

We are entering an era of chronic metabolic and cardiovascular multi-comorbidities. Amongst patients with type 2 diabetes mellitus (T2DM), cardiovascular disease (CVD) remains the main cause of mortality and morbidity [1]. Importantly, both habitually coexist against the background of obesity and insulin resistance: indeed, an extensive proportion of patients with CVD have pre-diabetes or T2DM, although these metabolic disorders are often undiagnosed [2]. Optimization and coordination of the – often complex – medical management of these patients is crucial, as it has direct implications for outcomes. By curtailing adverse CVD events, minimizing redundant testing and reducing drug-drug interactions, optimized cardiometabolic management can also have large benefits in terms of reducing medical expenditure. For example, the estimated 1-year cardiometabolic disease cost associated with a unhealthy diet in the USA amongst those aged 35–85 years is $301 per capita or a total population cost of $50.4 billion [3].

Numerous barriers will have to be overcome, however, to accomplish this goal. As of now, comprehensive primary and secondary prevention care plans addressing the complex issues of cardiometabolic patients are underdeveloped in most centers. Patients with metabolic diseases and CVD currently require the care of multiple specialists who work in parallel and with little interaction, with no 'main' specialist coordinating the management from an advanced, holistic standpoint. Endocrinologists may be uncomfortable prescribing drugs for CVD, and the same may be true for cardiologists when using novel drugs approved or in development for the treatment of patients with diabetes. Moreover, only a limited number of providers have extensive experience prescribing anti-obesity medication. This may result in the underuse of evidence-based, guideline-recommended class I therapies.

Indeed, recent advances in pharmacological therapy have resulted in the availability of 'cardiometabolic' drugs, which are FDA-approved to treat metabolic conditions such as obesity and diabetes while providing a proven CVD benefit. For instance, cardiovascular outcome trials (CVOTs) demonstrated that glucagon-like peptide-1 (GLP-1) receptor agonists as well as sodium-glucose transporter 2 (SGLT2) inhibitors significantly reduce major CVD events and are effective for glucose management. This has increased the attention towards the relevance of cardiometabolic patients, professionals, and their training.

Traditional models and silos of physician education and treatment presently in place will need to be reassessed. In this article, we review the shortcomings of current

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approaches and propose a training curriculum for a cardiometabolic specialist. We envision core concepts of cardiometabolic medicine to be introduced in medical school. A cardiometabolic clinical training program would include relevant parts of traditional endocrinology and cardiology programs with an important emphasis on lifestyle. In addition, in this review, we also expand the importance of other areas highly relevant to the cardiometabolic professional, such as biostatistics and epidemiology, lifestyle science with a special focus on dietary patterns, behavioral science and psychology, personalization of care, and creation of important collaborations with other specialties relevant to the cardiometabolic patient.

## Recent trends in the epidemiology of cardiometabolic disease

The overall body of literature suggests that the incidence of CVD has been declining over time [4]. However, although the rates of decline of CVD as well as heart disease and stroke mortality have decelerated in the last decade [5], projections even suggest that the prevalence of CVD in the USA may escalate by 10% until 2030 [6]. These trends may be attributed to the increasing prevalence of key CVD risk factors including the metabolic syndrome that encompasses central obesity, diabetes, dyslipidemia and hypertension. Moreover, not listed under the criteria for metabolic syndrome are other insulin-resistant paradigms that relate to CVD risk including nonalcoholic fatty liver disease (NAFLD), polycystic ovarian syndrome and pro-thrombotic and pro-inflammatory states [7].

### Obesity

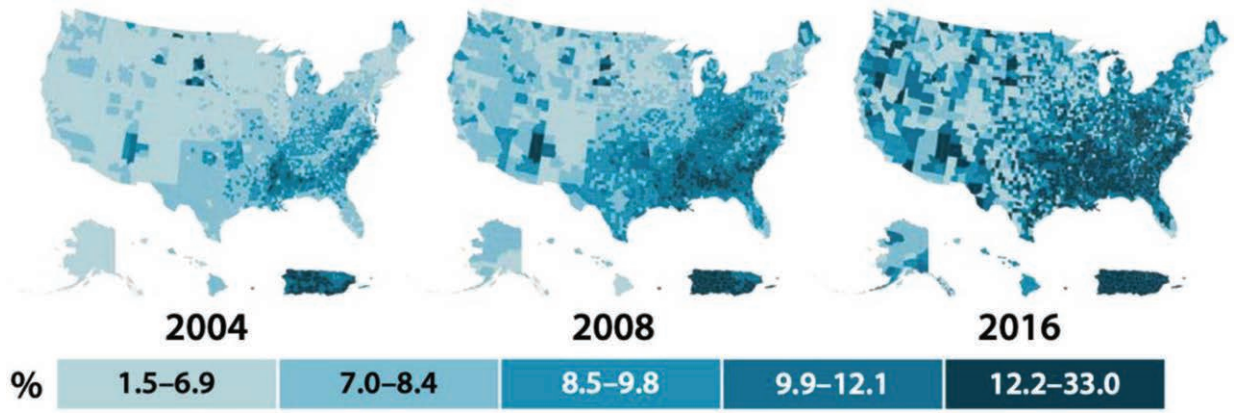
In 2017–2018, obesity prevalence of adults in the USA reached 42.4% and severe obesity 9.2% [8]. Estimates suggest that obesity prevalence in the USA will soar to 50% by 2030. Moreover, in 20 years, approximately one in four Americans is projected to be severely obese [9]. Individuals diagnosed with obesity have a much higher risk for CVD and diabetes than non-obese persons, as well as an elevated risk of developing other comorbidities [10]. A meta-analysis showed that each 1 SD increase in BMI increased the odds of coronary artery disease by 20% and T2DM by 67% [11]. As a consequence, a large portion of patients with CVD or at high risk of CVD are obese.

### Diabetes

Obesity is a major contributor to the diabetes pandemic (Fig. 1). Currently, 463 million people, comprising 8.8% of the world's population, are diagnosed with diabetes and >90% have T2DM [12]. Estimates by the International Diabetes Federation suggest that by 2045, cases of diabetes will rise to 700 million [12]. In North America, 13.3% of adults from ages 20–75 have diabetes and this number is expected to rise to 15% by 2045. In addition, the USA has one of the highest number of diabetes-related deaths worldwide [12]. Diabetes and even pre-diabetes range glucose levels are associated with multiple cardiovascular conditions and CVD is the leading cause of death in patients with these conditions. The relative risk (RR) for CVD for patients with diabetes lies between 1.6 and 2.6 [13].

Apart from diabetes, the prediabetic state is also a strong predictor of CVD and is highly prevalent among cardiometabolic patients [14,15]. Patients with prediabetes have greater extent of coronary atherosclerosis and plaque vulnerability [16]. In the Multi-Ethnic Study of Atherosclerosis, a diagnosis of prediabetes was associated with a 3-fold higher prevalence of unrecognized myocardial infarction [17]. Glycated hemoglobin levels in the

**Fig. 1**




Age-adjusted, county-level prevalence of diagnosed diabetes among adults aged 20 years or older, USA, 2004, 2008, and 2016. Data were unavailable for some US territories. Centers for Disease Control and Prevention. National Diabetes Statistics Report, 2020. Atlanta, GA: Centers for Disease Control and Prevention, U.S. Dept of Health and Human Services; 2020.

pre-diabetic range have been found to be associated with CVD [18].

#### Hypertension

Hypertension is another major risk factor for atherosclerotic CVD (ASCVD) and is closely linked to obesity and insulin resistance. Excess weight accounts for 65–78% of risk of essential hypertension [19]. It is well established that antihypertensive treatment reduces the risk of mortality and cardiovascular morbidity [20,21]. The prevalence of hypertension is rising in the USA, as is the proportion of patients receiving antihypertensive medications. However, as of 2015–2016, only 43.5% of individuals who were prescribed antihypertensive agents had controlled hypertension [22]. Hypertension is a common comorbidity of diabetes [23], with these patients being frequent recipients of multiple hypertensive drugs.

#### Dyslipidemia

Dyslipidemia is a key contributor in the development of atherosclerosis. Atherogenic dyslipidemia, characterized by elevated triglycerides and small dense-low density lipoprotein and reduced high-density lipoprotein cholesterol, is the most prevalent lipid abnormality among individuals with diabetes [24]. Prevalence of lipid abnormalities is higher among individuals with diabetes, contributing to their elevated cardiovascular risk [25].

#### Metabolic syndrome

The cluster of cardiovascular risk factors making up the metabolic syndrome and other parameters of insulin resistance are drivers in the underlying pathological processes of CVD and diabetes. Metabolic syndrome is associated with a RR for CVD of 2.88 for men and 2.25 for women, respectively [26]. The RR of T2DM, which is driven mostly by fasting plasma glucose, was also shown to be greatly increased for women (RR 6.90) as well as for men (RR 6.92) [26]. Despite prevalence of metabolic syndrome remaining stagnant, the total burden of metabolic syndrome is very high with an estimated one-third of all US adults and one-half of adults 60 years or older affected [27].

#### Cardiometabolic multimorbidity

While we are witnessing a rise in individual disease entities, prevalence of multimorbidity is increasing as well. A European survey on diabetes and heart disease reported that 31% of individuals with CAD were also diagnosed with diabetes [28]. A cohort study of almost two million participants showed that of individuals with T2DM, 17.9% had a manifestation of CVD, the most common being peripheral arterial disease (16.2%) and heart failure (14.1%) [29]. Evidence suggests that rates for hospitalization from HF are two-fold higher in patients with DM [30]. Moreover, recent evidence suggests that ECG evidence of silent myocardial infarction, which is more common among patients with diabetes, improves risk discrimination over and beyond traditional factors [31]. Obesity, diabetes and atrial fibrillation (AF) are closely related. Obesity-related diseases are mediated by regional fat deposits. For example, while pericardial fat is associated with CVD, it was also found to be a strong risk factor for AF [32].

## Advances in cardiometabolic drugs and limited real-world uptake

We are witnessing the development of pharmaceuticals targeting the variety of conditions associated with cardiometabolic disease. CVOTs demonstrated that some pharmaceuticals used to treat diabetes reduce important cardiovascular outcomes, as well as mitigate various CVD risk factors. DPP-4 inhibitors were safe but proved not to have any cardiovascular benefits compared to placebo. In contrast, the SGLT2 inhibitors [empagliflozin (EMPA-REG OUTCOME) [33], canagliflozin (CANVAS) and dapagliflozin (DECLARE-TIMI 58) [34]] have demonstrated significant reductions in CVD [35]. Canagliflozin, empagliflozin and dapagliflozin have additionally been shown to reduce the progression of kidney disease, as well as reduce incidence of hospitalization from heart failure [36–39]. Four FDA-approved GLP-1 receptor agonists [liraglutide (LEADER) [40], semaglutide (SUSTAIN-6) [41], albiglutide (Harmony Outcomes) [42] and dulaglutide (REWIND) [43]] have demonstrated significant reduction in CVD events. GLP-1 receptor agonists were additionally found to benefit patients with macroalbuminuria [44].

Based on this emerging evidence, the 2020 American Diabetes Association's Standards of Medical Care for patients with T2DM recommends the use of SGLT2 inhibitors as well as GLP-1 receptor agonists appropriate to mitigate cardiovascular risk in patients with diabetes [35]. An even more effective treatment of individuals with cardiometabolic disease may be offered through the development of novel, more potent GLP-1 agonists [45], In addition, patients with and without diabetes may also benefit from the further expansion of SGLT-2 inhibitors effective for individuals with heart failure with preserved ejection faction [46]. The formulation of an oral administration of semaglutide proved successful in multiple trials and will hopefully improve therapy adherence compared to injectable medication [47–49].

Despite their clear cardiovascular benefits and FDA approval of cardiovascular indication for these medications, these agents are underused in real-world clinical care. Estimates suggest less than 20% of patients with ASCVD and diabetes receive this guideline-recommended risk reduction treatment [50]. An evaluation of a large outpatient registry concluded that of potential eligible patients for SGLT2 inhibitors and GLP-1 agonists, only 5.2 and 6.0% were prescribed liraglutide and empagliflozin, respectively [51]. Broader and more targeted use

of these medications would likely lead to reductions in cardiovascular events and all-cause mortality.

## Current training program

While advancements in pharmacology continue to blur the lines between cardiology and endocrinology, physicians are still trained in siloed programs that are unfit for cardiometabolic patients with one or many co-morbidities that require requiring interdisciplinary style management. Even though cardiologists may seem well-positioned to take the 'lead' in managing cardiometabolic patients, many may be uncomfortable or uninterested in taking on patients' glycemic management, and prescribing weight-loss interventions and drugs. The treatment of ASCVD already requires management of multiple drugs and their side effects, such as statins, PCSK9 inhibitors, angiotensin-converting enzyme inhibitors, beta-blockers or dual antiplatelet agents or other anticoagulant regimens. Cardiologists may feel overwhelmed with additionally prescribing SGLT2 inhibitors and GLP-1 agonists and monitoring related side effects. In addition, there are patients on basal or basal/bolus insulin including the increasing number of patients with T1DM with CVD or high CVD risk [52]. Moreover, insulin infusion pumps and continuous glucose monitoring (CGM) are parts of the therapeutic management of patients with or at high risk of CVD.

Ultimately, the lack of interdisciplinary patient management results in fragmented care and worse outcomes for patients. There is a timely need for professionals who can manage complex, cardiometabolic patients in a comprehensive guideline-adherent manner.

## Core areas of training in cardiometabolic medicine

As cardiometabolic patients require the expertise of multiple specialists, they serve to benefit from the integration of knowledge and skills of relevant disciplines and multidisciplinary collaboration between health professionals. Therefore, and building on the notions discussed above, we strongly advocate for the development of a discrete field of cardiometabolic medicine. The cardiometabolic patient requires expertise across a wide range of specialties, including cardiology, endocrinology, primary care, nutrition, podiatry, neurology, nephrology, hepatology, pediatrics and family medicine and some key competences of these disciples should be incorporated into cardiometabolic training programs.

The following is a summary of the six core components of cardiometabolic training. Primary and secondary ASCVD prevention would be the main focus of the cardiology portion of the training program. With regard to primary ASCVD prevention, physicians would engage in advanced cardiovascular risk assessment training, including knowledge of risk calculators, risk enhancing factors and primary prevention pharmacology. Personalization of risk assessment to optimize preventive care is heavily endorsed by current guidelines, so training would include proficiency in CT imaging to obtain and analyze coronary artery calcium scores and evaluation of plaque burden [53].

To stay focused on cardiometabolic diseases, physicians would forgo training in electrophysiology, interventional cardiology, advanced heart failure, or cardiac transplantation. Instead, the program would concentrate on inpatient cardiac care, inpatient cardiology consults, preventive cardiology clinic, interpretation of electrocardiography, cardiac rehabilitation and cardiac imaging (echocardiography, stress testing, coronary computed tomography). To enhance expertise in management of severe hypertension, elective time would be spent in a multispecialty resistant hypertension clinic and vascular medicine.

The endocrinology portion of this program would cover metabolic diseases and provide trainees with sufficient clinical experience in T1DM, T2DM, obesity, lipid and lipoprotein disorders, and hypertension management. In addition, the program would include training in basal/bolus insulin administration, insulin infusion pumps and CGM. Rotations through lipid clinics to obtain expertise in handling complex lipid disorders would also be part of the endocrine component. Traditional parts of endocrinology training, such as thyroid, pituitary, reproductive endocrinology, metabolic bone disease and disorders of calcium metabolism would not be covered in the cardiometabolic training program. With ample evidence pointing to micro- and macrovascular complications in adulthood associated with childhood diabetes mellitus [54], components of pediatric diabetes management should be incorporated into the curriculum.

A substantial component of the cardiometabolic training program would be comprehensive lifestyle counseling. Trainees would gain a deep understanding of exercise physiology and nutrition including quality and quantity of diets, as well as smoking cessation, including cessation pharmacology and novel tobacco products. We also plan for behavioral intervention training to be an integral part of cardiometabolic training, with focus on physician-patient communication, motivational coaching, methods enhancing therapy adherence and mobile health strategies.

In addition, the cardiometabolic training program would incorporate the most relevant aspects of obesity medicine, that is, hepatology with focus on NAFLD and nephrology. With regard to obesity medicine, for example, physicians would rotate through multidisciplinary obesity clinics and obtain skills in individualized lifestyle management that promote weight reduction, obesity pharmacology and training and in referral to and postoperative management of patients undergoing bariatric (metabolic) surgery. Expertise of pediatricians regarding prevention of childhood

obesity should also be incorporated. Childhood overweight, particularly during puberty, is associated with increased risk of T2DM in adulthood [55]. Trainees would obtain this knowledge through rotations in pediatric obesity clinics.

## Enriching the breadth of cardiometabolic medicine even further

After completion of a 2- or 3-year general internal medicine program, fellowship training in the cardiometabolic specialist program would start. Besides the core training described above, we suggest adding the following components and complementary skills to enhance cardiometabolic training even further (Table 1 and Fig. 2).

### Epidemiology and biostats

Cardiometabolic disease is evolving into an ever-pressing public health problem. Current emphasis in epidemiological research on epidemiology modeling and economic endpoints will inform cardiometabolic physicians on the cost-effectiveness and health impact of prevention strategies, populations at risk and health disparities [56]. We are also witnessing the integration of 'big data' into CVD epidemiology. Digital technology in the form of wearable devices or in-the-body digital elements offer novel methods of epidemiological data collection [57]. This results in a much greater availability of epidemiological research information. In addition, an extensive number of biomarkers and risk scores characterizing the development of CVD has been developed. Therefore, it is vital for cardiometabolic medicine trainees to become adept at critical appraisal of scientific literature and to gain a nuanced understanding of the limitations of risk scoring methods [58]. We envision incorporating components of the Master of Public Health program into the cardiometabolic medicine training program. This would include formal epidemiology and biostatistics training, as well as instruction on principles for design and interpretation of clinical trials. Exposure to the public health system may be facilitated through clinical experience, such as rotations in community health centers or health department clinics.

### Behavioral science and psychology

During the cardiometabolic training program, physicians will learn skills for behavioral change counseling and methods to implement these in clinical practice through rotations with behavioral psychologists.

CVD development and outcomes are highly dependent on psychological factors. For instance, depression is an established risk factor for coronary heart disease (CHD), recurrent CHD events, and heart failure (HF) [56]. Depression is associated with poor outcomes in CVD, postcoronary bypass, and HF [56]. Diabetes distress and depression are also an important part of comprehensive diabetes assessment and therapy [59].

**Table 1 Overview of knowledge, skills and rotations of cardiometabolic medicine during residency and specialist training**

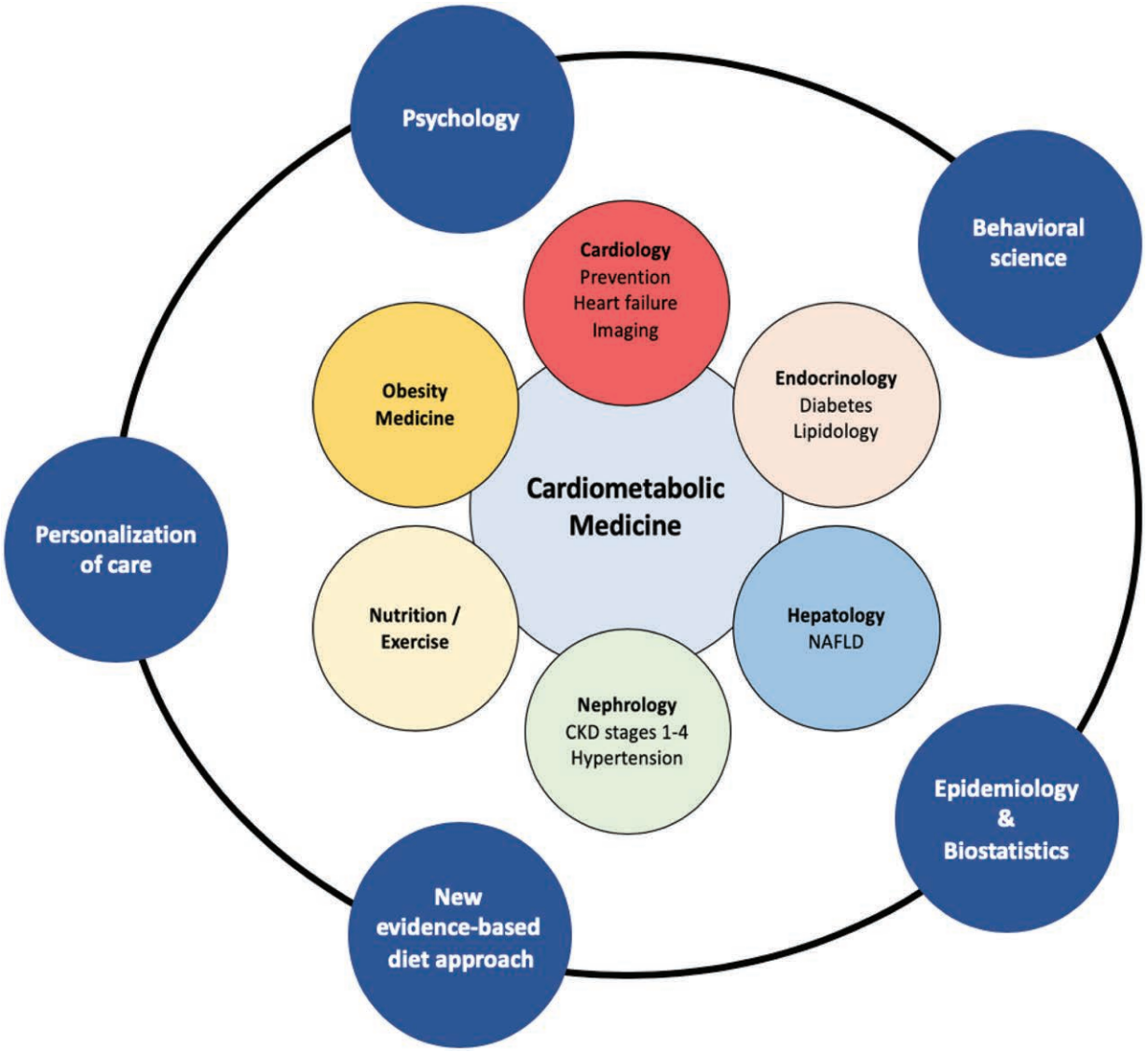
| Topic | Knowledge and skills |
|---|---|
| Endocrinology | Advanced glucose management |
| | Basal-bolus insulin management |
| | Insulin infusion pumps |
| | CGM |
| | Closed-loop systems |
| | Intensive insulin therapy |
| | Obesity clinic |
| | Obesity pharmacology |
| | Nutrition therapy |
| | Training in referral to bariatric surgery |
| | Management of patient's post-bariatric surgery |
| | Lipid clinic - management of patients with |
| | Statin intolerance |
| | Moderate to severe hypertriglyceridemia |
| | Genetic lipid and lipoprotein disorders |
| | Increases in lipoprotein (a) |
| Nephrology | Screening and treatment of CKD stages 1–4 |
| | Screening and treatment of microalbuminuria |
| Hepatology | Screening and treatment of NAFLD |
| Cardiology | Advanced cardiac imaging |
| | ECG interpretation |
| | CTA interpretation for cardiovascular risk estimation (CAC score as well as CCTA) |
| | Stress testing |
| | Echocardiography |
| | Hypertension management |
| | Vascular medicine |
| | Preventive cardiology clinic |
| | Inpatient cardiac care |
| | Inpatient cardiology consultations |
| | Cardiac rehabilitation |
| Epidemiology and biostatistics | Courses in epidemiology and biostatistics adapted from MPH programs |
| Leadership Training | Experience leading multidisciplinary clinical teams |
| Psychology | Psychological factors that affect the development of cardiometabolic diseases |
| | Knowledge of pharmacotherapy to treat psychological disorders such as depression and anxiety |
| | Knowledge of when referral to psychologist or psychiatrist is appropriate |
| Behavioral science | Advanced nutrition counseling |
| | Exercise counseling |
| | Smoking cessation counseling and pharmacology |

CAC, coronary artery calcium – highly specific feature of coronary atherosclerosis, which can be quantified using the Agatston score of a non-contrast, cardiac gated CT-image; CCTA, cardiac computed tomography angiography – heart and blood vessel imaging using computed tomography with iodine contrast injection; CGM, continuous glucose monitor – a sensor inserted under the skin measuring glucose levels continuously throughout day and night; CKD, chronic kidney disease – gradual loss of kidney function; CTA, computed tomography; MPH program, Master of Public Health – a master program focusing on public health issues, covering concepts such as epidemiology, biostatistics and behavioral science; NAFLD, nonalcoholic fatty liver disease – a condition where too much fat is stored in liver cells, not caused by too much alcohol consumption.

Patients' lifestyle behaviors are attributed to causing 40% of all deaths in the USA [60]. The WHO estimates that 75% of CVD could be avoided by four essential lifestyle practices: a healthy diet, physical activity, avoidance of tobacco, and moderate alcohol intake [61]. Despite clear evidence supporting the importance of a healthy lifestyle, propagation of this knowledge during medical school is minimal compared to time spent on pharmaceutical training [62].

In addition, adherence to prescribed medication is an issue, which could be addressed by behavioral change

**Fig. 2**




Fields of cardiometabolic medicine.

therapy. Approximately one-third of patients with and one-half of patients without a history of myocardial infarction do not adhere to prescribed medication [63].

Behavioral changes have been shown to result in robust, cost-effective improvements in outcomes [64,65]. Much evidence also suggests that weight loss counseling by physicians has a positive impact on patient's weight loss efforts and healthy eating habits [66,67]. However, simply explaining scientific facts to patients is insufficient to change behavior [68]. To facilitate any lasting behavioral transformation, physicians require a deep understanding of behavioral science principles, as well as tools to assist patients throughout the process of their lifestyle change [68].

**Nutrition**

The nutrition portion of cardiometabolic medicine training should stress critical evaluation of the dietary science literature to gain a deep understanding of how to best counsel patients regarding dietary interventions to optimize cardiometabolic health. This skill is best implemented by offering rotations with registered dieticians and certified diabetes care and educators.

The importance of nutrition in medicine is undisputed. A healthy diet is a key lifestyle habit with large implications for metabolic risk factors and CVD. Guidelines clearly stress the importance of nutritional intervention as part of evidence-based clinical care, however, specialists lack the education to implement these recommendations

[69]. A recent survey of 646 cardiologists stated that 90% received no or minimal education on nutrition counseling during their fellowship, even though 95% thought it was their responsibility to do so [70].

In addition, patients as well as physicians are confronted with novel 'healthy' diets almost on a daily basis. The list of popular diets is extensive, such as Mediterranean, DASH, Paleo, low-carb, low-fat diet and a plethora of fad diets. Physicians should emphasize that a cardioprotective diet consists of a divers inclusion of healthful foods, which permits flexibility and personal preference of patients [71].

A growing interest in dietary supplements also exists. However, evidence does not support the use of supplements to augment a cardioprotective diet with healthful foods and some supplements may even be harmful [72–74].

#### Personalization of care – sex and racial/ethnic-specific risk profiles of cardiometabolic diseases

In the light of a growing interest in developing a personalized approach to the prevention and treatment of cardiometabolic diseases, awareness of racial/ethnic and gender disparities should be emphasized during the cardiometabolic medicine training program. Cardiometabolic specialists should also be able to culturally adapt interventions to enhance therapy adherence.

An important heterogeneity in risk of developing cardiometabolic diseases exists within different ethnic groups. In particular, South Asian individuals have on average a heightened ASCVD risk and a four-fold risk of developing diabetes compared with white Europeans [75,76]. Evidence suggests that even though anthropometrically thin, South Asians are 'metabolically' obese, with greater visceral and hepatic fat even from infancy [77,78]. This may be reason for the observed development of T2DM at a much younger age and at lower levels of BMI [79].

Compared with whites and blacks, diabetes mellitus is disproportionally present in Hispanics. There is also a higher prevalence of metabolic syndrome in Mexican Americans compared to Puerto Ricans and white Americans. Hispanics are at greater risk of all-cause and CVD mortality than their white and Asian counterparts, despite similar atherosclerotic burden [80]. These differences may also be explained by socioeconomic disparities and healthcare access [80,81].

In the USA, the highest prevalence of overt diabetes exists in American Indians/Alaska Natives [82]. In addition, the highest rates of ASCVD risk factors are seen in this population compared to non-Hispanic whites. Engagement in activities that elevate risk for cardiometabolic disease may explain these observations. For example, 22.6% of Native American/Alaskan Natives adults are smokers, compared to 15% non-Hispanic white men, 14.6% of non-Hispanic black men, 9.8% of Hispanic men and 7.1% of Asian men [83]. Physical inactivity is also common. Estimates suggest that five in 10 Native Americans are physically inactive and 26.4% do not meet the FDA's recommended physical activity participation; a rate higher than in any other racial/ethnic group [84].

The cardiometabolic specialists should be aware of the sex-specific differences regarding metabolic and CVD. For instance, a history of premature menopause as well as pregnancy associated conditions, such as preeclampsia and gestational diabetes mellitus, increase ASCVD risk for women [85]. Sex-specific atherosclerotic plaque profiles exist as well. Evidence suggests that women are subject to more diffuse and extensive atherosclerosis, increasing their CVD risk [86]. Diabetes during pregnancy confers its own maternal and fetal risks, such as spontaneous abortions, fetal anomalies, neonatal hypoglycemia, among others. Diabetes during pregnancy may also increase risk of T2DM and obesity in the offspring [87].

#### Research skills

We envision that a focused training program on cardiometabolic medicine inspires new research ideas as a result of close collaboration between different disciplines. At the same time, cardiometabolic medicine specialists may also take jobs in an academic setting and lead important and novel investigations in basic, preclinical, clinical and population science and public health. Some studies in this field are amongst the highest impact in science and medicine. Therefore, projects require leadership of professionals with strong training in academic research. This could be facilitated by incorporating research electives into the training program.

## Cardiometabolic medicine as a longitudinal training curriculum – from medical school to lifelong learning

We envision a longitudinal training curriculum, with introduction of core concepts in medical school and the possibility of deepening this knowledge during specialization as a cardiometabolic physician. Life-long learning in this field will be ensured by offering continuing medical education (CME) programs.

#### Medical school

We hope that students will be interested in the cardiometabolic specialty, as many medical students strive to 'make a difference' in clinical care and clinical research. In this sense, cardiometabolic medicine is appealing because it focuses on conditions which affect an extremely large proportion of patients.

Medical education focuses little on prevention of cardiovascular and metabolic diseases but places disproportionally more emphasis on mechanisms behind the chronic

disease states and pharmaceutical management. Further, diseases are taught as single entities, but many patients are diagnosed with multiple conditions that often have similar mechanisms, for example, insulin resistance, that all have to be managed simultaneously. A course in cardiometabolic medicine would offer a historic and holistic perspective on preventive medicine, and provide students with the skills to treat complex, multimorbid patients. In Table 2, we provide an overview of the specific skills important to the cardiometabolic specialist which are lacking in current curricula.

How would a cardiometabolic training program in medical school be implemented? Some argue that medical school programs are already overloaded with expanding medical knowledge. However, we propose that rather than adding cardiometabolic medicine as a completely separate specialty to the curriculum, concepts could be integrated into existing content. For example, a recent trend in medical education is restructuring education around disease entities instead of the arbitrary boundaries of organ system blocks. Existing content such as T1DM/T2DM and ASCVD classically covered within separate endocrine organ systems and cardiology, respectively, could instead be taught within a holistic cardiometabolic medicine course. Many medical universities have adopted longitudinal integrated clerkships, in which students are assigned to a preceptor and patient and train within this disciple and care for this patient for a year. Cardiometabolic patients are the optimal patients for this type of curriculum, as they are currently required to see an extensive number of specialists. This would provide students with the opportunity to learn from many different physicians by following these patients from visit to visit.

This framework of knowledge and skills would be valuable to all physicians, including students who do not choose to specialize in cardiometabolic medicine. For example, lessons on behavioral science are easily transferable to other specialties that engage in direct patient care.

Overall, we hope to offer medical students an early exposure to cardiometabolic medicine by providing students with foundation knowledge of this disciple.

### Specialty training

We believe that the formulation of cardiometabolic specialist program would further enhance the ability of internal medicine physicians to manage complex patients with cardiometabolic disease. While many internal medicine residents might be interested in metabolic diseases or ASCVD, currently they still spend many months of training in catheterization or electrophysiology labs or learn about thyroid disease, bone health, or endocrinologic cancers. This time could be instead invested on specific skills and concepts truly relevant to facilitate the comprehensive treatment for the cardiometabolic patient. In addition, recognition of a cardiometabolic specialty would lead to more innovative research ideas through the closer collaboration amongst the variety disciples. More research dedicated exclusively to cardiometabolic disease would ultimately improve patient care in the long run.

### Continuing medical education and lifelong learning

We believe that the skills of the cardiometabolic specialist are very much needed among professionals who already completed their specialty training. Training modules, online courses and CME training could be offered to effectively distribute these skills amongst already specialized physicians. We also envision a separate journal dedicated to cardiometabolic medicine as a medium to share the latest advancements in research in this disciple.

## Gaps and future directions

To enhance the cardiometabolic education program even further, more research is needed to identify the training

**Table 2 Knowledge and skills of cardiometabolic medicine in medical school**

| Topic | Knowledge and skills |
|---|---|
| Behavioral science | Core concepts of major behavior change theories (Motivational Interviewing, 5 A's Algorithm) |
| | Behavior change techniques (goal-setting, self-monitoring, reinforcement) |
| Nutrition | Describe dietary guidelines for maintenance of health and prevention of disease |
| | Assess patient's dietary behaviors |
| | Diagnose and manage nutrition-related problems |
| Smoking cessation | Pathophysiology of smoking addiction |
| | Smoking cessation pharmacology |
| | Behavioral science courses in smoking cessation techniques |
| Exercise physiology | Knowledge of benefits and contraindications of endurance and strength training for primary and secondary prevention |
| | Ability to prescribe exercise with the suitable intensity |
| | Awareness of how comorbidities affect exercise performance |
| Epidemiology and biostatistics | Cost-benefit analysis of health interventions |
| | Knowledge of general epidemiology and risk factors of cardiometabolic disease |
| | Interpretation and knowledge of limitations of cardiovascular risk scores (Framingham, PCE etc.) |
| Cardiometabolic pharmacology | "Cardiometabolic" agents (SGLT2 inhibitors, GLP-1 agonists) |
| | Knowledge of drug-drug interactions used in cardiometabolic medicine |
| | Pharmacological dosing adjusted for age, gender, race/ethnicity and comorbidities |

5 A's Algorithm: The interventions 'Assess, advise, agree, assist, arrange' implemented in health behavior change programs.
GLP-1, glucagon-like peptide-1; PCE, pooled cohort equation; cardiovascular risk assessment score, estimating the 10-year risk of ASCVD event; SGLT2, sodium-glucose transporter 2.

needs of different groups of relevant professionals seeing cardiometabolic patients. The cardiometabolic medicine training program proposed here also has to be developed in more detail to ensure adherence to guidelines and patient safety. We hope the cardiometabolic specialty will gain momentum by initially integrating it into existing cardiology and endocrinology training programs.

Finally, we envision a 'cardiometabolic clinic' where physicians and other specialists work together collaboratively in interdisciplinary teams. The optimal cardiometabolic team would consist of cardiometabolic specialists, dieticians, diabetes care and education specialists (formally called CDEs), exercise physiologists, specialized rehabilitation physicians and behavioral psychologists. Rehabilitation facilities as well as outpatient clinics would be an integral part of the cardiometabolic clinic.

### Conclusion

The dire need to treat the cardiometabolic disease epidemic while providing cost-effective, high-quality healthcare is one of the most important health challenges of the 21st century. Introducing cardiometabolic medicine as a separate specialty with a comprehensive training program starting in medical school and extending until after specialization is the most effective method to tackle this enormous task. Prevention, treatment and management of risk factors of cardiometabolic disease are best achieved by a less siloed approach with cardiometabolic specialists working collaboratively with other specialists in interdisciplinary teams.

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### Conflicts of interest

R.H.E. has served on scientific advisory boards for KOWA, Novo Nordisk as well as for the cardiovascular outcome trial PROMINENT (Pemafibrate to Reduce Cardiovascular Outcomes by Reducing Triglycerides in Patients with Diabetes).

M.J.B. has served on scientific advisory boards for Amgen, Sanofi, Regeneron, Novartis, Novo Nordisk, Bayer and Akcea. For the remaining authors, there are no conflicts of interest.

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