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RESEARCH ARTICLE

The Coronary Artery Risk Detection in Appalachian Communities (CARDIAC) Project: An 18 Year Review

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Abstract: ***Background*:** The Coronary Artery Risk Detection in Appalachian Communities (CARDIAC) Project is a chronic disease risk factor surveillance, intervention, and research initiative aimed at combating the unacceptably high prevalence of heart disease, diabetes, and other chronic illnesses in West Virginia.

***Objectives and Methods*:** The school-based public health project identifies health risk factors in children, educates families, informs primary care physicians, and provides resources to schools to help improve population health, beginning with children.

***Results and Conclusion*:** Details regarding methodology, results, and conclusions derived from this unique public health initiative that has screened over 200,000 children are the subject of this 18-year review.

Keywords: CARDIAC, chronic disease, risk factor, surveillance, intervention, strategies.

1. INTRODUCTION

The Coronary Artery Risk Detection in Appalachian Communities (CARDIAC) Project is a chronic disease risk factor surveillance, intervention, and research initiative aimed at combating the unacceptably high prevalence of heart disease, diabetes, and other chronic illnesses in West Virginia. The initial goal of the CARDIAC Project when it was implemented in elementary schools in West Virginia during the 1998-1999 school year was to identify dyslipidemic children and their parents, and apply novel intervention strategies [1, 2]. Our aim was to test the hypothesis that universal blood cholesterol screening of children in a rural population with the highest prevalence of heart disease in the nation was preferable to selective screening based upon family history of premature coronary disease, as was recommended by the National Cholesterol Education Program (NCEP). A decade later, retrospective analysis of LDL-C levels among 20,266 5th grade children revealed that 37% of those with possible familial hypercholesterolemia (LDL>160 mg/dL.) would have been missed based on guidelines applicable at the time [3].

Equally concerning, however, is that nearly half (47%) of West Virginia children are either overweight or obese, with those on the higher end of the weight scale having comorbidities reflective of metabolic syndrome. Many had not been previously identified or given advice on weight man agement by their health care provider. The high prevalence of obesity, the associated clustering of CVD risk factors, and the low identification rate by physicians is supportive of alternative approaches such as school-based programs [4].

As a state at the forefront of the obesity epidemic, West Virginia is experiencing immense health and economic costs as a result. Collaboration with state and local partners and regular dissemination of our findings have been key elements in addressing the situation. Comprehensive health reports that include BMI seems to have affected parents' management of their children's dietary intake, physical activity, and health care [5]. Moreover, nearly two decades of risk-factor screening have influenced public policy at the state and national level [6].

Sustaining a school-based surveillance, intervention, and research project in every West Virginia county over the last eighteen years would not have been possible without several key factors. The platform upon which screenings were originally conducted was the WV Rural Health Education Partnership (WVRHEP), created by the state legislature in 1990. It required all health science students from the state's three medical schools to spend several months in rural rotations to expose them to the health disparities of underserved populations. This strategy gradually achieved its intent of addressing the maldistribution of physicians and allied health professionals throughout rural communities.

Financial support by the West Virginia legislature on an annual basis has also been a key factor in assuring sustainability because it funds the core cost of conducting the program. Additional support from private foundations has enabled many of the interventions implemented over the years, and federal grants have supported research, such as "Ad-

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Table 1. CARDIAC project aims and objectives.

WV CARDIAC Project Aims	
• To reduce heart disease mortality to the national average by 2020 through identification of individuals at high-risk and referral for treatment • To reduce childhood obesity through partnerships with educational agencies, state government, local communities, and the private sector	
Project Component	**Primary Objective**
Surveillance	Provide accurate and comprehensive school-based assessment of risk of chronic diseases such as diabetes, heart disease, and obesity to parents, their physicians, state government, and other public health stakeholders
Intervention	Support the application of population-based health interventional strategies targeting children and their families
Research	Apply high-level analysis of acquired data so as to accurately inform health promotion and disease prevention strategies in homes, communities, schools, and clinical practice

dressing Familial Hypercholesterolemia: A Model Program for States" (Centers for Disease and Prevention, CDC), and "Dyslipidemia Detection in West Virginia" (National Heart, Lung, and Blood Institute, NHLBI). Thus, the CARDIAC Project has grown from a small pilot project conducted among 349 children in 3 of the state's 55 counties in 1998 to over 200,000 children from every West Virginia school district 18 years later (see project aims and objectives in Table **1**). Details regarding methodology, results, and conclusions derived from this unique public health initiative are the subject of this review.

2. SURVEILLANCE

The primary focus of the CARDIAC Project school-based comprehensive health screening is to assess health risk factors of fifth grade children enrolled in schools in WV. Fifth grade children were selected because this age group falls into the recommended guidelines for lipid screening. The screenings began in 3 counties with 349 children in 1998, and expanded to 9008 children in all 55 counties by 2004. In addition to expanding geographically, CARDIAC also increased the screenings to include additional grade levels, and has at one time included kindergarten, second, eighth and ninth grade students. For children in grades other than 5th grade, a limited number of assessments were conducted which typically included a family history questionnaire, measurement of Body Mass Index (BMI), and screening for acanthosis nigricans (AN).

Written consent to offer screenings is required of each school superintendent in the fifty-five counties in the state. Signed active consent of parents and the child's assent is required of all 5th graders to participate. Enacted in 2008, passive consent from parents of children in other grades is allowed where only BMI/AN screening is taking place, if approved by the county school superintendent. Through this procedure, families are informed of the upcoming screening, and if parents do not want their child to participate, they are asked to specifically decline in writing prior to the screening date.

At the inception of the CARDIAC Project, regional RHEP coordinators and health science students were tasked with scheduling screenings and visiting schools. During the pre-screening visits, coordinators provided an overview of the project, screening procedures, and educational information about health-related risk factors and practices prior to screening date. In project year 2010-2011, WVRHEP dissolved as an organization. Therefore, the CARDIAC Project now employs six Area Coordinators (AC) to conduct screenings in schools in six geographic regions around the state. The AC team is physician-led and made up of individuals with bachelors and masters degrees, mostly in social sciences. All ACs had been coordinators in the former WVRHEP. ACs participate in yearly training with the complete CARDIAC Team, comprised of physicians and other health care providers, central staff, nutrition and physical activity professionals, behavioral specialists, and school intervention specialists.

CARDIAC consent packets, including a family health history questionnaire and a descriptive booklet about the project, are sent home to the parents/guardians of children eligible for screening. All procedures are approved by the Institutional Review Board at West Virginia University. Approximately one week before the screenings takes place, the ACs collect returned forms and distribute to the CARDIAC central office for processing.

2.1. Comprehensive Health Screening Procedures

For schools in all consenting counties that have agreed to participate, the following assessments and procedures are used with all consented 5th grade students:

2.2.1. Body Composition

Children's height and weight are assessed after shoes, hats, and extra clothing are removed using SECA Road Rod stadiometers and SECO 840 digital scales (SECA Corp, Hanover, Md, USA). Body Mass Index (BMI) is then calculated using *EpiInfo*. Age and gender specific growth charts are compared to each child's BMI values to calculate BMI percentile using CDC Growth Charts [7]. BMI percentiles are then recorded into categories: underweight (0-4.9th percentile), healthy weight (5-84.9th percentile), overweight (85-94.9th percentile), obese (95-98.9th percentile) and severely obese (99th percentile and above).

2.2.2. Blood Pressure

Two resting blood pressure measurements are completed using a Welch Ally Cuff (NY, USA), and if significantly

different from one another, a third measurement is conducted. Pressures are adjusted for height, age, and gender to calculate blood pressure percentiles. Systolic and/or diastolic pressures > 95th percentile are recorded as abnormal.

2.2.3. Prediabetes Screening

Participants are screened for possible insulin resistance using the acanthosis nigricans (AN) marker. AN is characterized as a raised, pigmented rash on the neck or axilla. CARDIAC screening incorporates an exam of the back and base of each child's neck to screen for the marker. Screening personnel report either the presence or absence of AN on the screening form.

2.2.4. Lipid Analyses

In years one through four of the project, lipids were measured by a fasting finger-stick of total blood cholesterol (TC) and high-density lipoprotein (HDL) using a portable CHOLES-TECH LDX analyzer (Perigon, Chicago, IL). In year five, the project transitioned to fasting lipid profiles. Trained volunteer phlebotomists from local communities collect the fasting blood sample from each participating child. All samples are forwarded and analyzed by a commercial reference laboratory or local hospital. Results include total cholesterol (TC), low-density lipoprotein (LDL), very low-density lipoprotein (VLDL), high-density lipoprotein (HDL), and triglycerides (TRIG). Children who are identified with AN receive additional blood testing for insulin and glucose.

2.2. Reporting

Between 4 to 6 weeks after screening, a parent of each screened child receives a health report including screening values by mail. The report includes the health findings and health behavior change recommendations based on screening results. The CARDIAC Hotline fields phone calls from parents with questions about the health report and recommendations. Parents are also encouraged to access a dedicated social media site with educational messaging and a communications component. Results and recommendations are also shared with the primary care physician if authorized by the parent/guardian on the consent form, as well as school nurses for appropriate follow-up and recording. A personal phone call is made to each parent and parent-identified physician if the child's results show triglycerides are >500, glucose is >125, systolic blood pressure is > 175, and LDL cholesterol is > 190. In addition, the parents of participating children receive a voucher to get their fasting lipid profile measured at no cost at a commercial reference laboratory. The CARDIAC Project identifies and refers for treatment children and relatives with familial hypercholesterolemia (FH). To date, the CARDIAC Project has identified over 600 5th grade children who have highly probable genetic dyslipidemia, which, if treated, has the greatest potential to decrease heart disease in West Virginia.

2.3. Children's Screening Results

The CARDIAC Project has screened 98,970 fifth graders, 20,003 kindergarteners, 91,516 second graders, 5,897 eighth graders, and 8,709 ninth graders. For the fifth graders who are under active consent, participation rates have ranged anywhere from 26-49% of eligible students. For those grades using the passive consent process (kindergarten and second grade) participation rates have ranged from 73-82% of eligible students. A summary of the children's screening results since the project inception is provided in Table **2**. West Virginia children's BMI averages for 5th graders reveal that 18.7% are overweight (at or above 85th percentile), and 28.4% are obese (at or above 95th percentile). Examining BMI cumulative results across grades and years, children who were overweight and obese (at or above 85th percentile) progressively increased from kindergarten (33.9%), to 2nd grade (37.7%) to 5th grade (47.1 %).

2.4. Overview of Analysis of 5th Grade Children's Results

As only 5th grade children had blood pressure and blood lipid measurement, in addition to BMI and AN screening, their results are presented in Table 2 and summarized as follows:

Nearly a quarter (23.2%) of children screened were identified as having hypertension, and 25.0% showed abnormal lipid values (LDL >130 and HDL <40). The most common lipid abnormality was low HDL values, which is highly correlated with obesity and lack of physical activity. A subset of children with AN (n=1579) had insulin resistance (IR) measured [Homeostatic Model Assessment for Insulin Resistance (HOMA-IR index)], with positive results in 60.9%. CARDIAC data revealed that obesity negatively affects all other risk factors assessed, and that those that are classified as severely obese have the highest prevalence of risk factors compatible with the metabolic syndrome [8].

2.5. Parents Screening Results

With their child's results, parents/guardians are given a voucher to take to a local certified laboratory to get their own lipid panels completed as part of the CARDIAC Project. To date, 5,416 parents (for 4,612 unique children) were screened (1.3% of fathers and 4.4% of mothers) between 1999 and 2016. Of those screened, 56.9% had abnormal lipids, defined as either a low HDL or a high total cholesterol. A closer look at the results stratified by gender revealed that most of the parents participating were females (N = 4,075 female, N = 1,341 male). Participating male parents/guardians had greater prevalence of dyslipidemia than their female counterparts; 41.2% of males versus 17.2% of participating females had low HDL (< 40); and similarly, 28.9% of females had LDL ≥ 130 and 8.1% had LDL ≥ 160, while 41.3% of males had LDL ≥ 130 and 14% had LDL ≥ 160. A CARDIAC study of parent participation in screening found that parents who chose to participate in the free screening opportunity tended to be more educated, more aware of family history CV risk factors, and less likely to smoke. Furthermore, the study did not find that parents were more likely to participate if their child's screening results found them at risk, nor did results show that a biased sample of parents who have extreme cardiovascular risk factor were the ones who chose to participate [9].

Table 2. Demographics and outcomes for 5th grade CARDIAC participants, N = 99,282, 1999-2016.

Variable	N or Mean	Valid % or SD
Age		
Mean (SD)	10.95	0.55
Race		
Black	2,594	2.9%
White	84,105	92.8%
Asian	418	0.5%
Hispanic	685	0.8%
Bi-Racial	2,395	2.6%
Other	452	0.5%
Gender		
Male	46,529	46.9%
Female	52,750	53.1%
Father Education		
8th grade or less	1294	2.7%
Some high school	4588	9.7%
High school/GED	18152	38.3%
Some college or technical	12380	26.1%
College graduate	7803	16.5%
Completed graduate school	3184	6.7%
Maternal Education		
8th grade or less	1437	2.1%
Some high school	4762	7.0%
High school/GED	22542	33.1%
Some college or technical	19389	28.4%
College graduate	15205	22.3%
Completed graduate school	4824	7.1%
Smoking in the home (year 5 – current)	29,758	33.7%
Family history of heart disease	5,847	31.8%
Family history of high cholesterol	22,356	33.8%
Family history of diabetes	39,006	51.7%
Screening Outcomes		
Participation Rate	98, 970*	38.6%
Overweight	18,176	18.7%
Obese	27,636	28.4%
Hypertension	20,510	23.2%
LDL ≥ 130	4,640	7.2%
HDL < 40	11,414	17.8%
Acanthosis Nigricans (AN)	4,471	5.0%
Of those with AN, HOMA > 3	1,579	60.9%

*had BMI conducted.

2.6. Surveillance Summary

In summarizing surveillance over the last 18 years of the Project, there have been minor changes in procedures related to available resources and personnel. However, most practices have remained constant throughout. Unequivocally, collaboration with state and local partners is essential to the success and sustainability of the Project. Additionally, regular dissemination of de-identified aggregate data is another key approach taken throughout and has led to intervention, research, and policy implementations, as discussed below.

3. INTERVENTIONS

The CARDIAC Project realizes the critical need to assist in providing interventional strategies to facilitate knowledge, positive attitudes, and desired behaviors in children and their families related to health risk factors - particularly physical activity (PA) and nutrition. Currently, members of the CARDIAC Team are involved in health-related interventions with individual children, with schools and communities, and with policy change.

These evidence-informed interventions are those that are based on knowledge grounded in research, participants' needs and preferences, and professional wisdom (physicians, researchers, experts in the field). Environmental and cultural relevance is important to the selection of specific interventions to meet the needs of the people served (families, children, school personnel, community leaders). The CARDIAC interventional strategies have been prioritized over the years by those that 1) increase awareness, 2) educate, 3) foster positive attitudes and facilitate behavior change, and 4) lead to systems and policy changes in local communities, and the state.

One way to categorize the presentation of CARDIAC interventions is to display them according to parallel features or targets. Adapting the tenets and terminology from Bronfenbrenner's Ecological Systems Theory [10], the Micro-, Meso-, Macro-levels provide a reasonable framework to help represent intervention foci from individual to policy change, keeping in mind that one level will influence the other and should be seen as interactive and with blurred boundaries [11]. For our purposes in categorizing interventions, the Micro Level with be those interventions that influence individuals through physician counseling, individualized educational programs, and family involvement; the Meso Level are those that provide programs, resources, and evidence-informed practices to schools and communities; and the Macro Level indicates CARDIAC's involvement in providing science-based evidence and expertise to influence policy changes at the state and national levels.

3.1. Micro-level Interventions

At the micro level of individual interventions, the screening process itself provided the initial strategy to intervene with children and their parents. Educational materials were sent to families prior to screening consent, educational sessions were provided for children in the school setting, and follow-up information with health behavior change recommendations was sent to parents with screening results. Currently, those practices have been updated, and involve parent-identified primary care physicians (PCPs) to be included in screening results and follow-up. Other modes of communication with parents have been established, including website pages, and targeted parent educational messaging through dedicated social media outlets (cardiacwv.org).

Initially, the first population-based interventions targeting individual change in children focused on using school-based strategies to reach the student population. In 2002, an online instructional module for fifth-grade students, *Healthy Hearts 4 Kids,* was offered to all 5th grade teachers and their students in WV schools to be used as a supplement to the school health curriculum. A similar module was developed soon thereafter targeting middle school students, *Take Charge! Be Healthy* (takechargebehealthy.org). [12] In 2008, a multidisciplinary team of health professionals, healthcare providers, and researchers developed *Camp NEW (Nutrition, Exercise, and Weight Management) You* to target those children identified as at-risk through the CARDIAC screening (campnewyou.org). Three cohorts participated in the year-long program (2008-2011), where children attended a two-week residential summer camp and three follow-up weekends during the year. The program included parent education sessions and group and individual counseling sessions, along with physical activity and dietary intake monitoring.

The Project's physician-led interventions include The Preventive Cardiology Clinics for Children and Adolescents (*i.e*. Lipid Clinics). The Lipid Clinics are offered through West Virginia University School of Medicine, Department of Pediatrics, and are available in five locations geographically distributed across the state. Housed in available hospital or clinic space in cooperation with other medical centers, they provide consultative services for children and their parents who have severe dyslipidemia. The clinic team is comprised of pediatric cardiologists and nutrition counselors. Exercise physiologists and genetic counselors are available for consultation as needed.

Of particular interest are children and their families who have been identified with a diagnosis of possible or probable familial hypercholesterolemia (FH). As an autosomal dominant disorder, it confers a twenty-fold increased probability of coronary heart disease as compared to the normal population and is inherited from one or rarely both parents. FH is one of the most common genetic diseases affecting the cardiovascular system, and affects approximately 1 in 270 individuals. It is estimated that less than 10% of those with the disease have been diagnosed. Data from the CARDIAC Project screenings identify and contact parents of children with LDL-C levels > 160 mg/dl. They are provided educational materials about FH, cascade screening options, and follow-up with physicians in the Lipid Clinics. Parents of children with LDL-C > 190mg/dL, or elevated fasting blood sugars, receive a personal phone call from CARDIAC physician staff strongly urging repeat laboratory test and evaluation. See a description of all Micro-level interventions in Table **3**.

3.2. Meso-level Interventions

CARDIAC community level interventions at the Meso Level began with the development of *West Virginia on the Move* (WVOM), a national initiative supported first by the National Governor's Association. This initiative brought

Table 3. CARDIAC project interventions overview.

Micro Level the individual level	**CARDIAC Screening Participation** - CARDIAC Area Coordinators provide educational sessions in schools with scheduled screenings; parents receive a health report including screening results and recommendations; parent-identified PCPs receive screening information for follow-up; the toll-free CARDIAC Hotline for parents and school nurses is available for questions/concerns regarding screening, results, or recommendations (1998-present)
	Parent Educational Materials -website page and social media pages are dedicated to educating parents about CARDIAC screening, interventions, and healthy lifestyle behaviors (2004 – present)
	Healthy Hearts 4 Kids (healthyhearts4kids.org) –a web-based instructional module for 5th grade children focused on cardiovascular health, physical activity, nutrition, tobacco use; provided to schools to enhance health curriculum (1998-2014)
	Take Charge! Be Healthy (takechargebehealthy.org) – a web-based instructional module for middle school students (6-8th grade) focused on physical activity, nutrition, weight management; provided to schools to enhance health curriculum (2008-present)
	NEW (nutrition, exercise, and weight management) You Program –a free, after-school program for children (10-14) with two or more risk factors for CVD, (BMI greater than the 95th percentile), and their parents to participate in a nutrition education and PA program aimed at building healthy lifestyles for families. Offered in two community fitness centers in WV Princeton Health and Fitness Center, Tygart Valley Rehabilitation and Fitness Center). (2006-2015)
	Camp NEW YOU (campnewyou.org) - The Camp NEW (nutrition, exercise, weight management) You Program was designed to help adolescent children (ages 11-14) and their families identify and practice lifestyle changes that will assist in reducing unhealthy body weight through increased physical activity, decreased sedentary time, and good nutrition. Yearlong program beginning with a 2 week residential camp, with an additional 3 follow-up family weekends; funded by 4 state health insurance agencies (2008-2011)
	WV Games for Health Project – an initiative to provide overweight children a planned Dance, Dance, Revolution (DDR) exercise program to increase their daily physical activity levels (2006-09)
	School Veggie Tastings – an educational program offered to WV schools in select counties for elementary students that encourage eating more vegetables, and assisting teachers in incorporating veggie tasting throughout the curriculum. (2009-2011)
	The CARDIAC Kinder, Too, and Teen Project - designed to examine prevalence of CVD risk factors and knowledge, attitudes, and behaviors related to healthy lifestyle habits in the K, 2nd, and 8th/9th grade age groups; taught children and their parents about physical activity through the use of a step counter, and educated them on obesity related issues, including good nutrition and physical activity (2003-present)
	Active WV: RX for Health Project – initiative focused on physician involvement in promoting health-enhancing physical activity to patients while connecting them to West Virginia's outdoor opportunities through the use of WV State Parks. (2013-14)
	The Preventative Cardiology Clinic for Children and Adolescents – clinics offered in 5 locations in WV to provide consultative services for children and their parents who have severe dyslipidemia; CARDIAC directors (pediatric cardiologists) provide services in the clinics, and refer at-risk CARDIAC participants (1975 – present)
Meso Level the community level	**WV On the Move (WVOM): Schools on the Move Grant Program** grants up to $5,000 each, available for school-based projects/programs improving access to physical activity opportunities Since 2005, 64 grants were awarded to schools in 31 West Virginia counties to increase physical activity opportunities and environments for students, staff and families, funded by WVU Children's Hospital. (2005-2014)
	Active Academics (activeacademics.org) – Active Academics® is a resource for classroom teachers to provide practical physical activity ideas that can be integrated into regular classroom content areas. (2006-present)
	Greenbrier CHOICES Project (greenbrierchoices.org) – a district-based 3-pronged intervention to enhance middle school physical and health education curriculum and healthy school environments, to serve as a referral system for pediatric obesity treatment and intervention at school-based health centers and local regional healthcare specialists, and to encourage family and community involvement at the local level. (2010-13)
	McDowell CHOICES Project (mcdowellchoices.org) – a district-wide school intervention to enhance physical activity opportunities at school through the provision of comprehensive school physical activity programs (CSPAP) including quality physical education (PE) , before and after-school programs, physical activity opportunities during the school day, staff involvement, and family and community engagement. (2013-16)
	WV Healthy Resources Directory - Provided physicians, school nurses, and other health care professionals with an online resource directory of individuals and facilities in each county who can be contacted for individual or group services related to physical activity, nutrition, and/or weight management (2005-2007)

Table 3 Contd…

Meso Level the community level	**Nursing Education Initiative –CARING –** nursing students design, deliver, and evaluation a school-based health education program on topics that impact CVH, work with at-risk children and their parents to impact knowledge, attitudes, and behaviors, and coordinate efforts to educate physicians about CARDIAC. (2005-2007)
	4-H Health Initiative – CARDIAC partnered with WVU Extension Service to add a health component to the 4-H curriculum for monthly meetings that included the addition of a 4-H health officer, health knowledge and motivational ideas to improve every-day health behaviors with youth and their families**.** The 4-H Health Initiative also included the Healthy 4-H Camp Challenge - implemented a camp curriculum that included nutrition and physical activity educational messages and activities; and Cardiac Family Fun, where invited families of at-risk children identified through CARDIAC screening attended family fun nights in select locations around the state that included physical activity participation and healthy cooking (2005-present)
	Let's Move Active Schools (letsmoveschools.org) collaborated with the WV Department of Education to be the first state to get one school in every county registered for this national initiative in 2012, and first state to have ALL elementary schools registered in 2015. (2012-present)
	School Wellness Policy Workshops - one day workshops in 7 state regions to educate and stimulate local collaboration for implementation of School Wellness Policies in all WV schools (2007-2009)
Macro Level the policy level	**Influencing National Youth Screening Guidelines** – retrospective analysis of blood cholesterol measurement among a large cohort of children (20,266) revealed that selective or targeted screening based on family history would have missed 37% of those with significant dyslipidemia (LDL-C > 160 mg/dL), supporting AAP and NHLBI to recommend universal screening among children and adolescents. (2011)
	WV Physical Activity Plan (wvphysicalactivity.org) – CARDIAC team members oversaw the development, and now dissemination and evaluation, of a state plan released in Jan 2012 using the National Physical Activity Plan framework to create a statewide culture that facilitates physically active lifestyles in every societal sector and in every region of the state, regardless of socio-demographic factors, or other potential barriers; the Plan sector teams are multiple partners representing stakeholders from 8 population sectors (2012 – present)
	WVDE Policy 2510 – Increase PA in schools by 30 minutes not including physical education; CARDIAC team members provided scientific evidence of need; advocacy; post workshops for teachers (passed 2014 to present)
	WV HB 2816 WV Healthy Lifestyles Act –mandated BMI screening; required PE time; fitness testing; drink machines removed from schools; CARDIAC team members provided scientific evidence of need; conducted evaluation; conducts school BMI screenings (passed 2005 to present)
	WV Physical Education Content Standards – led by WV Dept of Education, content standards were developed for the instruction of physical education in all K-12 schools; CARDIAC team member served on development committee; post workshops (2003)

together major stakeholders to focus on physical activity as a primary risk factor in disease prevention, and to promote increased physical activity opportunities for and participation of all citizens of our state. The *WVOM Schools on the Move Program* became one of the first initiatives to award schools, through a competitive process, funding to provide those opportunities in the school setting. Another school-based intervention developed by the CARDIAC Project team is an online teacher resource, *Active Academics* (*AA*) (activeacademics.org) [13]. *AA* is designed to help classroom teachers integrate more physical activity into the classroom environment, and throughout the school day. To date, AA has 4850 registered users. Two large district-wide school initiatives have been implemented to promote Comprehensive School Physical Activity. Both three-year initiatives focus on improving children's physical activity participation, and therefore, improved BMI [14, 15]. The Greenbrier CHOICES Project also included a clinical component for pediatric obesity treatment and intervention at school-based health centers and local pediatrician offices. See a description of all Meso-level interventions in Table **3**.

3.3. Macro-level Interventions

Current literature supports the need for more investment in macro level interventional strategies in order to have a more profound impact on the obesogenic environment [16] The CARDIAC Project's impact on policy and practice within WV and beyond is attributed to the comprehensive focus on chronic disease prevention, the scope of the project, and its ongoing success and influence. CARDIAC Team members have contributed to a number of macro-level actions that have affected policy and systems change to potentially affect whole populations. The most impact to date has been on school-related policy change. Additionally, the implementation and evaluation of the WV Physical Activity Plan is still underway, but has the potential to be a robust public health initiative for behavior change that can potentially affect chronic disease morbidity and mortality in WV [17]. Periodic consultation with the governor's office, legislative leadership, and state agencies has led to substantive discussion and actions related to health policy. Although there are fewer macro-level interventions identified, developing and influencing policy is a complex process with multiple levels of capacity building, multidisciplinary interaction and cooperation, and investment of time. The ongoing interventions noted in this section are being implemented and evaluated, and are proving to be sustainable. See a description of all Macro-level interventions in Table **3**.

3.4. Interventions Summary

To summarize CARDIAC interventions over the years, a multi-strategy approach involving all levels of society have been implemented, targeting individuals to the population at large. Targeted interventions will continue to include strategies at the micro-, meso-, and macro levels. Partnerships are critical to the success of all interventions. CARDIAC has partnered with other individuals, groups, organizations, and agencies to identify successful interventions, to assist in the development of new interventions, or to collaborate in their delivery. Partners focused on similar goals enhance knowledge and experience, share resources, support collaborative efforts, improve outreach to stakeholders, and work toward a common social change. The CARDIAC Project's success is attributed to successful partnerships throughout all aspects of the project.

4. RESEARCH

Within the larger CARDIAC project, research staff and faculty are responsible for publications, presentations, medical referring, IRB, data analysis, data aggregation, data distribution, and hotline calls. A data summary of 5th grade CARDIAC data is available in Table **2**. In this section, research productivity of CARDIAC is outlined, specifically highlighting three publications resulting in strong clinical implications with some updates from more recent years' data.

4.1. Improvements in Health Outcomes

State and national organizations often look at CARDIAC project data to determine whether obesity trends are improving. In 2014, a CARDIAC publication documented decreases in LDL cholesterol [18]; however, these improvements did not extend to improvements in BMI. An updated figure is presented to show these trends including CARDIAC years 15 and 16 (Fig. **1**). The article notes that these decreasing LDL (but not obesity) trends are reflected in other USA datasets as well [19].

4.2. Relationships Between Obesity and Cholesterol in 5TH Grade Childres

Many CARDIAC research endeavors have focussed on the relationship between obesity and associated co-morbidities. It is interesting to note that the prevalence of hypercholesterolemia doubles in the presence of obesity, from approximately 6% among normal weight children to about 12% when weight is above normal, for an odds ratio of 2.0. However, elevation in LDL-C associated with obesity is generally mild (LDL-C < 140 mg/dL). Nearly nine out of ten overweight or obese children do not have hypercholesterolemia. And notably, cholesterol risk, particularly with LDL and total cholesterol, does not continue to increase as weight status increases. This suggests that the major determinant of blood cholesterol level is genetic, with much less influence due to environmental factors. It should be noted that LDL particle size has become a part of evaluation of metabolic syndrome but metabolic syndrome is without definition in children. Particle size measurement was not common in 1998 at the start of the CARDIAC Project and has been beyond the scope of available funds for CARDIAC.

By way of contrast, co-morbidities associated with the metabolic syndrome progressively worsen as weight status increases. This includes hypertension, low HDL-C, high triglycerides, and AN. The relative validity of AN as a surrogate for insulin resistance is shown by finding an elevated

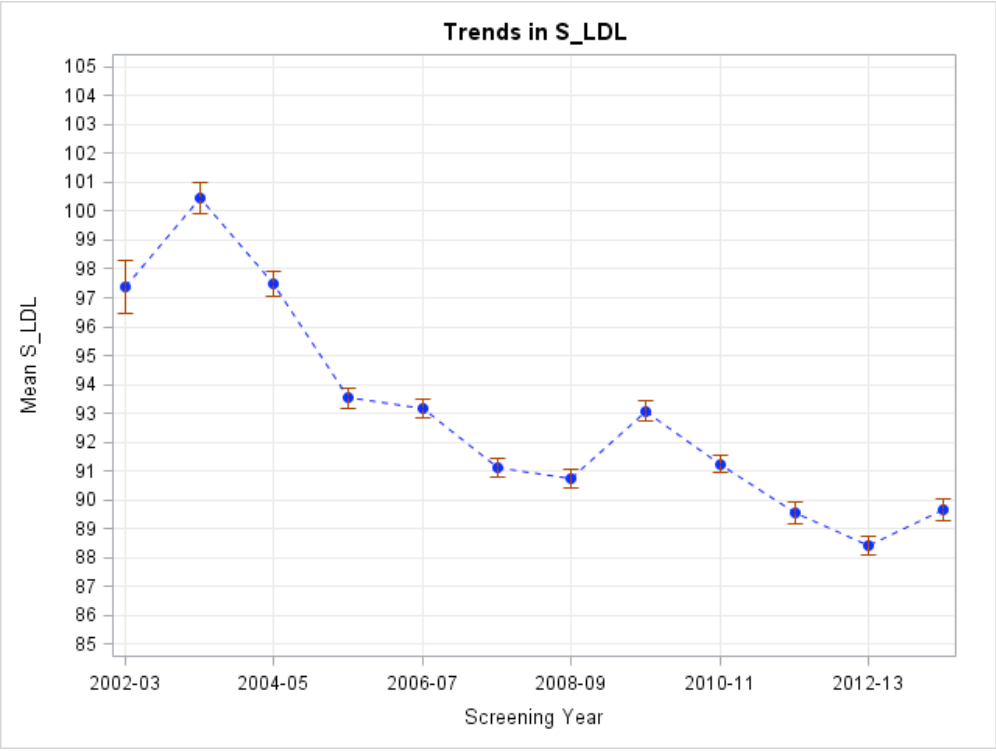

Fig. (1). Trends in LDL Cholesterol Decreases Over 12 Years.

HOMA > 3.0 in 60.9 % of children with this marker. Among morbidly obese children approximately one-third have clinical evidence of pre-diabetes [20] (Table **4**).

4.3. Genetic Hypercholesterolemia

Between 1998 and 2015 60,404 5th grade children had lipid profile measurement. An LDL-C > 160 mg/dL suggests a genetic etiology, such as familial hypercholesterolemia (FH). The prevalence of moderately severe hypercholesterolemia among this cohort is as follows:

LDL> 160 mg/dL: 637 (1.1%)

LDL> 175 mg/dL: 248 (0.4%)

LDL> 190 mg/dL: 122 (0.2%)

An LDL level above 175 mg/dL approximates recently published data suggesting the presence of FH in 1/270 children [21]. To clarify, the cutpoint of 175 mg/dL was arbitrarily selected as the half-way point between an LDL of 160 at which one would consider the possibility of FH when there is a strong family history of premature heart disease; and an LDL of 190 mg/dL, the point at which there is significant likelihood of FH. One cannot be more definitive than this arbitrary cutpoint since genetic testing for FH is extremely limited in the U.S. When genetic testing is done a positive mutation is found variously between 60-80% of the time. Diagnosis at this time is primarily based on phenotypic criteria.

4.4. Changing Clinical and Health Policy

In 2010, CARDIAC data revealed that selective screening practices based on a family history of premature heart disease and significant dyslipidemia excludes a large percentage of students who have likely genetically high cholesterol (3). This finding has been cited as part of the debate as to whether universal pediatric lipid screening was justified [22-24]. Universal cholesterol screening is now recommended for all children between 9 and 11 years of age [25], a recommendation facilitated by CARDIAC's school-based screening method for the detection of familial hypercholesterolemia.

4.5. RESEARCH SUMMARY

In summary, our data confirms the presence of undifferentiated genetic dyslipidemia in approximately 1% of children, unrelated to weight status. An LDL-C > 175 mg/dL more strongly suggests the possibility of heterozygous familial hypercholesterolemia, and was present in 1/250 children. Application of selective screening guidelines based on positive family history of premature CHD would have missed one-third of these children, thereby negating the opportunity to interrupt lifelong exposure to its deleterious effects.

In contrast to blood cholesterol, as weight status increases from normal to overweight to morbidly obese co-morbidities associated with metabolic syndrome become progressively more prevalent.

5. IMPLICATIONS FOR PRIMARY CARE

Primary care providers are important contributors to public health – particularly disease prevention. In recent years, physicians are taking a more active role in health promotion, and engaging in more preventive health practices for children and their families, particularly in helping them to adopt healthy lifestyles. For those at-risk, physicians not only diagnose, but counsel patients on how to engage in change that can modify their risk factors.

The CARDIAC Project has demonstrated the need for health screenings in children, diagnosis of health risks, and interventions for both prevention and treatment. Physician

Table 4. Relationship between obesity and associated co-morbidities.

Risk factor (% of students)	Underweight/ Normal weight	Overweight BMI 85th – 94th %	Obese BMI 95th – 99th %	Morbidly Obese BMI above 99th %
Elevated BP N = 16,278 (23.1%)	5,478 (15.1%)	3,091 (22.9%)	5,221 (32.8%)	2,488 (51.7%)
Elevated TC N = 4,747 (8.6%)	1,766 (6.1%)	966 (9.2%)	1,577 (13.0%) [A]	438 (12.2%) [A]
Low HDL-C N = 9,851 (17.9%)	2,624 (9.0%)	1,866 (17.9%)	3,761 (31.1%)	1,600 (44.7%)
Elevated LDL-C N = 4,054 (7.4%)	1,407 (4.8%)	885 (8.5%)	1,370 (11.4%) [B]	392 (11.0%) [B]
Elevated TRIG N = 6,384 (11.6%)	1,180 (4.1%)	1,274 (12.2%)	2,817 (23.3%)	1,113 (31.1%)
Positive for AN N = 3,560 (5.0%)	187 (0.5%)	283 (2.1%)	1,536 (9.8%)	1,554 (32.6%)

Means with the same letter in their superscripts do not significantly differ from one another. All other comparisons by weight category were significant, P 0.05.
Year 6 to 16. BP: SBP or DBP >=95th%ile. TC >=200. low HDL < 40. LDL >=130. TRIG >= 150.
Percent's describe those with risk factor within each weight group.

engagement at the Micro-, Meso-, and Macro- levels are all important influences in the promotion of healthy behaviors and treatment related to risk factors that may influence early onset of chronic disease.

5.1. Engagement at the Individual/ Family Level

Engagement at the individual and family level is the most significant influence that physicians have in positive health change. Screening, diagnosis, treatment, and intervention are all practices that contribute to improved health of their patients.

5.1.1. Screening Children

BMI is an appropriate measure for screening for obesity in children using the CDC Growth Charts, as described previously. It should be used as a general indicator of potential weight problems in individuals, not as a diagnostic tool. Other health assessments, such as family history of comorbidities, lipid profile, insulin resistance, and a physical examination should also be included. Repeated health assessments and regular updates to medical history should be considered as changes will take place over time.

Despite extensive evidence supporting universal blood cholesterol screening at ages 9 to 11 years and 17 to 21 years by the National Heart Lung and Blood Institute (NHLBI) and the American Academy of Pediatrics (AAP) published in 2011 [26], uncertainty remains because the United States Preventive Services Task Force (USPSTF) reaffirms its positon that there is insufficient evidence that cholesterol measurement in children prevents heart disease in adults, and therefore, concludes that there is insufficient evidence to recommend for or against universal screening of children. [27]. However, there is unequivocal evidence that early screening identifies the approximately 1/270 children with familial hypercholesterolemia [21]. Early treatment of these children avoids prolonged exposure to elevated LDL-C, known to lead to premature CHD. Practitioners are urged to follow universal screening guidelines, not only on behalf of the children at greatest risk, but also their parents and first degree relatives, half of whom will have FH as well.

The concern of some that BMI and blood cholesterol screening may lead to overuse of statins is unfounded. As we have shown, nearly 90% of overweight or obese children do not have hypercholesterolemia, and there has been no documentation of overuse of statins among children in this country or elsewhere.

5.1.2. Treatment of Identified Risk Factors

Research has shown that physicians are often times ill-prepared, unwilling, or unequipped to treat patients who are obese. Patient-physician communication is often influenced by the physician's attitude toward the patient, and it is well documented that physicians often have negative attitudes toward obese patients [28]. One study found that parents perceived physicians as non-thorough, rushed, and indifferent to their child's weight status, did not include children in the conversation about solutions, and did not follow-up [29]. Often times, this has been influenced by physicians' perceptions that effort have been ineffective in the past, or is due to a need for more education on effective strategies for counseling children and their parents. One technique that has proven effective in physician-patient communication is motivational interviewing [30]. Motivational interviewing is a method to help physicians engage in meaningful conversation with their patients to elicit behavior change. Many resources to help with motivational interviewing are now available for healthcare providers, including a new initiative of the American Academy of Pediatrics Institute for Healthy Childhood Weight, called *Change Talk* (www.aap.org). This free app and web resource is available for download from app stores or accessed through the website.

Treatment for those identified with probable FH or significant dyslipidemia require physicians to become well-informed about FH and cholesterol in children. High cholesterol in children is primarily due to heredity, but is adversely impacted by poor diet and sedentary activity. An excellent resource for practitioners is the Familial Hypercholesterolemia Foundation (FHF) website, which provides information on diagnosis, management and family screening (fhfoundation.org). An inclusive list of guidelines for cardiovascular health and risk reduction in children is also well-outlined in the National Heart, Lung, and Blood Institute's Current Clinical Practice Guidelines and Reports [31]. Additionally, The American Heart Association provides helpful guidelines for CVH promotion in children, guidelines for identification of children at high risk of CVD, and guidelines for CV risk reduction through interventions for children and adolescents [32].

5.1.3. Child and Family Intervention

Parents and children/adolescents see their primary care physician (PCP) as someone they can trust to give them valuable and resourceful health information and advice. Therefore, PCPs should have a plan for providing their patients with this information, and then continually monitor patient status and progress in developing and maintaining healthy lifestyles.

PCPs should provide information about physical activity and nutrition, and encourage the use of available resources for families that can be used at home to increase physical activity participation and healthy dietary habits. Prescribing physical activity or dietary intake and then tracking patient progress is another way to intervene in the home environment and encourage personal goal setting. Exercise is Medicine is a global health initiative that provides information and tactics for physicians to prescribe physical activity for prevention, treatment and management of chronic disease [33].

One highly recommended intervention for physicians is the 5210 Let's Go! Campaign. A nationally recognized, evidence-based childhood obesity prevention initiative, this program focuses on educational messaging targeting children to eat 5 fruits and vegetables, limit recreational screen time to 2 hours or less, participate in 1 hour of physical activity, and drink 0 sugary beverages each day. The program provides online toolkits for healthcare providers that outline strategies for connecting with community, measuring BMI, and talking with patients and families. It also provides a plethora of educational handouts for children and parents, and an evaluation framework. (letsgo.org/)

To help families take control of their dietary and physical activity patterns, several strategies have proven to be helpful. They include providing information and resources that focus on how to make changes and manage the home environment, goal setting, monitoring progress, rewarding success, and overcoming barriers. Parenting skills are also an important contributor to success, including positive role modeling, and setting and reinforcing reasonable and acceptable boundaries.

The 2015-2020 Dietary Guidelines for Americans [34] and the 2008 Physical Activity Guidelines for Americans [35] provide the recommended amounts and types of foods and physical activity that should be targeted daily.

5.2. Engagement at the Community and Policy Levels

Many physicians want to be engaged in social and economic issues that affect their patients' health in the environments in which they live, work, and play. Pediatricians and family practitioners are especially interested in community participation [36]. Engagement in community initiatives are needed to provide advocacy, expertise, and support from the healthcare sector lens. Service to the community is seen by many as a connector to their patients, and their lives outside the office doors.

Additionally, some physicians see an interaction between medicine, service, and policy. Engagement in policy development, support, and/or enactment can help shape policy from the healthcare prospective, including health issues that affect the population, in general. Physicians are trusted professionals and can therefore, have a positive influence with the public. In most cases, a physician's medical expertise and status in society are seen as extremely useful in the political process. They also have unique insights into the needs of the public from a patient viewpoint that can drive policy change.

Through experience from the CARDIAC Project over the years, expertise and participation of physicians in all areas have proven to be imperative to the success of the Project endeavors. They have been represented in surveillance efforts, in application of interventions at the individual, community, and policy levels, and as researchers in various studies. Some examples include:

- Provide service through sharing expertise and serving on committees for school boards, school wellness committees, community action groups, etc
- Work with specific interventions as reviewers, experts, clinical evaluators, on-site medical assistance
- Send referrals to local programs aimed at providing services and programs to at-risk children and their families
- Encourage funding support for local initiatives in schools and communities
- Serve on statewide teams to advocate for statewide plans and policy

CONCLUSION

A synthesis of the facilitators to the success of The CARDIAC Project as an effective, comprehensive public health initiative in West Virginia reveals a number of key enablers to our success. State-appropriated funding has provided the core funding for the operational costs of conducting the program. Additional support from private foundations has enabled us to provide many of the interventions, and federal grants have been leveraged to conduct research. Being housed at a university with a medical college, a children's hospital, and many other allied health colleges, has allowed for a multidisciplinary team working in surveillance, interventions, and research. Additionally, infrastructure for program delivery was in place at the onset by coordinating with the WV Rural Health Education Partnership. Finally, the state and county school systems have been supportive and cooperative throughout.

The Coronary Artery Risk Detection in Appalachian Communities (CARDIAC) Project has completed nearly two decades of surveillance of the health status of West Virginia's youth. Comprehensive screening of BMI, blood pressure, lipid profile, and markers of insulin resistance has identified over 600 5th grade children who have highly probable genetic dyslipidemia, some of whom require pharmacologic treatment. Further, nearly half of these children are overweight or obese, informing individualized and population-based interventional strategies directed toward adopting a healthier lifestyle. The CARDIAC Project's ongoing engagement in policy development and support can continue to help shape health policy and practices in West Virginia and beyond.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The above-referenced research study was reviewed by the West Virginia University Institutional Review Board IRB and was approved in accordance with 46 CFR 46.101b.

HUMAN AND ANIMAL RIGHTS

No Animals were used for studies. All humans research procedures followed were in accordance with the ethical standards of the committee responsible for human experimentation(institutional and national), and with the Helsinki Declaration of 1975, as revised in 2008.

CONSENT FOR PUBLICATION

All participants provided the written informed consent.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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Project by Ms. Paula Nicholson, and data entry by Ms. Emily Polak have successfully guided surveillance of over 200,000 subjects. Many individuals and partners have participated in a wide variety of interventional strategies, without whom CARDIAC's focus on a healthier West Virginia would not have been possible.

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