Original Research Article

Improving Health Outcomes in Rural India:
The AAPI Adopt a Village Project's Approach to Non-Communicable Disease Screening and Prevention

Manju Ramakrishnan, MBBS[1]*, Maureen Kennedy, DrPH, MS[2], Padmini Murthy, M.D., MPH[2], Murthy Gokula, M.D.[3], Samhita Nair, MSBS[4], Chaitanya Shanti Vanamada, MBBS[5], Veerapaneni Kiran, MBBS[5], Kavya Sudireddy, MBBS[6], Nikhila Gandrakota, M.D., MPH[7]

[1]Rollins School of Public Health, Emory University, Atlanta, GA, US
[2]Epidemiology and Global Health, New York Medical College, Valhalla, NY, USA
[3]Department of Family Medicine, University of Toledo, Toledo, OH, USA
[4]Christian Brothers University, Memphis, TN, USA
[5]ACS Medical College and Hospital, Chennai, TN, India
[6]Apollo Institute of Medical Sciences and Research, Hyderabad, TS, India
[7]Department of Family and Preventive Medicine, Emory University School of Medicine, Atlanta, GA USA

Edited by:
Niharika Khanna, M.D., DGO

Reviewers:
Janaki Deepak, MBBS
Univ. of Maryland School of Medicine Baltimore, MD,

Suni Niranjan Jani, M.D., MPH
Community Behavioral Health Columbia, MD,

Correspondence: *dr.manju147@gmail.com*

Received: *December 22, 2023*
Accepted: *April 4, 2024*

Citation: *Ramakrishnan et al, JAAPI 3(2,3):37-51, 2023*

Abstract:

Introduction: Noncommunicable diseases (NCDs) account for 85% of premature deaths in low to middle-income countries. A strategic approach to reduce NCDs in rural populations must meet the United Nation's 2015 Sustainable Development Goals. Our study aims to improve screening of NCDs, and promote lifestyle changes, thereby preventing NCDs in rural India.

Methods: American Association of Physicians of Indian Origin (AAPI) and Global Tele Clinics (GTC) have launched this ongoing screening program for NCDs in 75 villages across India. Phase-1 involves screening for hypertension, diabetes mellitus, anemia, obesity, hyperlipidemia, and chronic kidney disease. Phase-2 involves continuity of care by healthcare professionals for these patients, and Phase-3 aims to create an economically sustainable model.

Results: A total of 5541 people in 51 villages across five Indian states were screened for six NCDs. Hypertension (50·7% of females and 57·9% of males), and anemia (30·5% of females and 44·6% of males) were the most common conditions detected. Obesity was found in 44·1% of females and 38·7% of males. Hyperlipidemia was observed in 22·8% of females, and 9·6% of males, with an LDL >100 mg/dl in 59·0% of females and 58·1% of males. Elevated creatinine was found in 45·1% of females and 22·0% of males. Elevated serum creatinine, an indicator for CKD, accounted for the largest percentage of a first diagnosis for those less than 30 years old (36.8%). Initial diagnosis of hypertension was also increased to 47.7% for those 30 to 50 years old, and to 66.3% for those greater than 50 years old. A significant degree of comorbid conditions was also found. Of those diagnosed with diabetes mellitus (HbA1c ≥ 6.5%), 64.5% were also hypertensive, 51.4% were categorized as obese according to the Asia-Pacific Classification. Close to 30% of those with an HbA1c ≥

6.5% demonstrated border(line) hyperlipidemia and elevated creatinine. The distributions of hypertension, elevated creatinine, border(line) hyperlipidemia, and high lipidemia were consistent across both the overweight and obese categories according to the Asia-Pacific and WHO classifications. Hypertension was the most prevalent comorbidity for those overweight or obese (57.4% to 65.1%) followed by elevated creatinine (31.2% to 36.0%) and border(line) hyperlipidemia (21.0% to 28.7%).

Conclusion: The prevalence of NCDs and comorbid conditions has increased in rural India due to lifestyle changes, inadequate healthcare access, and awareness. Our study evaluated the feasibility of hybrid healthcare delivery model and identified gaps and concerns in providing efficient patient care. Our program seeks to promote a hybrid prevention and management model which will increase NCD screening and improve the overall health of the rural communities of India.

Keywords: Non-communicable Diseases, Rural India, Screening, Health Care Access, Prevention, and Management

Abbreviations Used	
AAPI	American Association of Physicians of Indian Origin
AHA	American Heart Association
CBC	Complete Blood Count
CDC	Centers for Disease Control and Prevention
CKD	Chronic Kidney Disease
DALYs	Disability-Adjusted Life Year
DIPAM	Digitally Integrated Prevention and Management
GTC	Global Tele Clinics
HbA1C	Glycated Hemoglobin
ICMR-INDIAB	Indian Council of Medical Research-India Diabetes
LDL	Low-density Lipoprotein
LDL-C	Low-density Lipoprotein Cholesterol
NCD	Non-Communicable Disease
PHC	Primary Healthcare Center
SRL	Super Religare Laboratories
NFHS	National Family Health Survey
WHO	World Health Organization

Introduction:

As reported by the World Health Organization (WHO) and the US Centers for Disease Control and Prevention (CDC), noncommunicable diseases (NCDs) are responsible for 71% of deaths worldwide (1, 2). Furthermore, 85% of premature NCD deaths occur in the middle to low-socioeconomic areas of developing countries, such as Ethiopia, Nigeria, Bangladesh, India, et cetera (2). Studies have shown that in tropical regions like India, NCDs accounted for a rise in morbidity measured by the Disability-Adjusted Life Years (DALYs) and contributed to 61·8% of total deaths (3). These countries have exhibited a major epidemiologic transition, with NCDs now causing prolonged suffering and death at younger ages compared to high-income countries (1).

Screening and management of NCDs have largely been neglected across India (4). In rural areas of India, this issue is exacerbated due to limited access to health screening, inadequate health promotion, health education, and a lack of preventive practices. Lack of education and awareness could lead millions of individuals to continue unhealthy dietary practices, alcohol and tobacco use with inadequate management of elevated blood pressure levels and high body mass index (5).

Social determinants like education, income levels, occupation, and gender also play a role in the rise of NCDs (5). With NCDs requiring treatment for several years and often life-long treatment, a never-ending cycle is created, where vulnerable patients are plagued by diseases that lead them into poverty-prone situations, secondary to expenses incurred by treatment (4). This emphasizes that initiating strategies and practices across the health, social, and economic sectors is imperative with screening programs for NCDs and creating actionable next steps to reduce the disease burden in rural populations.

One of the targets of WHO's Sustainable Development Goal 3 is Good Health and Well-Being. It aims to reduce the levels of premature mortality caused by NCDs by at least a third (relative to 2015), an important milestone to address the prevalence of chronic diseases and advance from disease management to disease prevention (1, 6, 7). A strategic approach would allow for the strengthening of health systems for the early detection and management of risk factors. Through our approach to raising awareness of disease management and prevention for the reversal of NCDs in rural India, we hope not only to improve health outcomes but also to establish a continuous and coordinated care model by partnering with healthcare professionals.

Thus, the purpose of this study is to provide healthcare screening for NCDs like hypertension, diabetes, anemia, chronic kidney disease, obesity, and hyperlipidemia, and to diagnose, prevent, and potentially reverse these diseases through a hybrid model of healthcare delivery involving

direct patient care and digital clinics as well as adequate lifestyle modifications in rural India.

Methods: In March 2022, the American Association of Physicians of Indian Origin (AAPI) celebrated India's 75 years of independence by initiating a screening program for non-communicable diseases (NCDs) in 75 rural villages across different states in India, including Andhra Pradesh, Gujarat, Himachal Pradesh, Karnataka, Tamil Nadu, and Telangana. The project aimed to assess the accessibility of doctors, nurses, and health assistants in rural primary healthcare centers (PHCs) and screen the population for six major NCDs, namely hypertension, diabetes mellitus, hyperlipidemia, chronic kidney disease, anemia, and obesity. The ethical clearance for the project was obtained from the institutional ethical committee of ACS Medical College Hospital, Chennai, India, a constituent unit of Dr. M.G.R. Educational and Research Institute in Tamil Nadu state. Thus, strict guidelines in conducting research involving human subjects were followed.

We designed a three-phase project to screen, evaluate, and create a sustainable program for NCDs over two to three years. The primary phase involved conducting a screening program in the adopted villages for the six NCDs, using a standardized screening protocol. The second phase is focused on managing positive patients for the six diseases and education on disease management and prevention. In-person visits will be conducted once a month, and a daily digital clinic will be set up in the evenings for three hours. These clinics will predominantly utilize a digital integration prevention and management model of care (DIPAM).

The third phase of the project is planned to focus on creating an economic model to ensure the program's sustainability. This involved identifying potential funding sources and developing a plan for resource allocation, as well as building partnerships with local governments, non-governmental organizations (NGOs), and private companies.

To screen for non-communicable diseases in rural areas of India, AAPI partnered with Global Tele Clinics (GTC), a startup company from Hyderabad, India with 12 years of experience in NCD screening. A memorandum of understanding was signed between AAPI and GTC to screen villages for six NCDs in three phases over two to three years. In the first phase, a willing sponsor who is an AAPI member had chosen a village of his/her preference to adopt. The screening program begins with physical examinations and laboratory tests, including CBC, HbA1c, lipid profile, serum creatinine, and pulse oximetry reading in addition to the measurement of blood pressure, height, and weight fulfilled by SRL (Super Religare Laboratories, Chennai, India). Approximately 150–200 patients were screened per village in phase one, to screen 75 villages across India by the end of 2023. As of September 2022, 51 villages had been screened. This manuscript's data includes the outcomes from the screening of these 51 villages. The process is illustrated in Figure 1 and the project road map is in Figure 2.

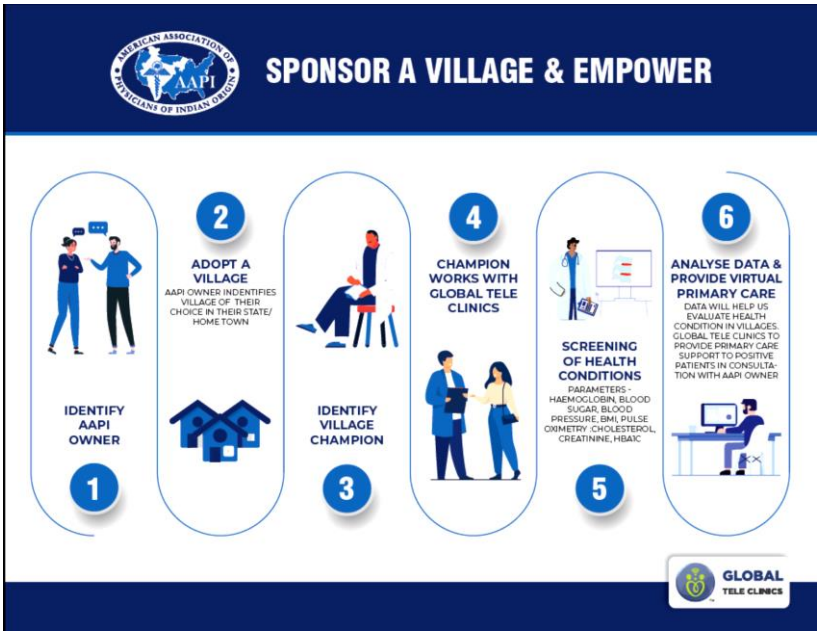


Figure 1: Outline of "Adopt a Village" Project

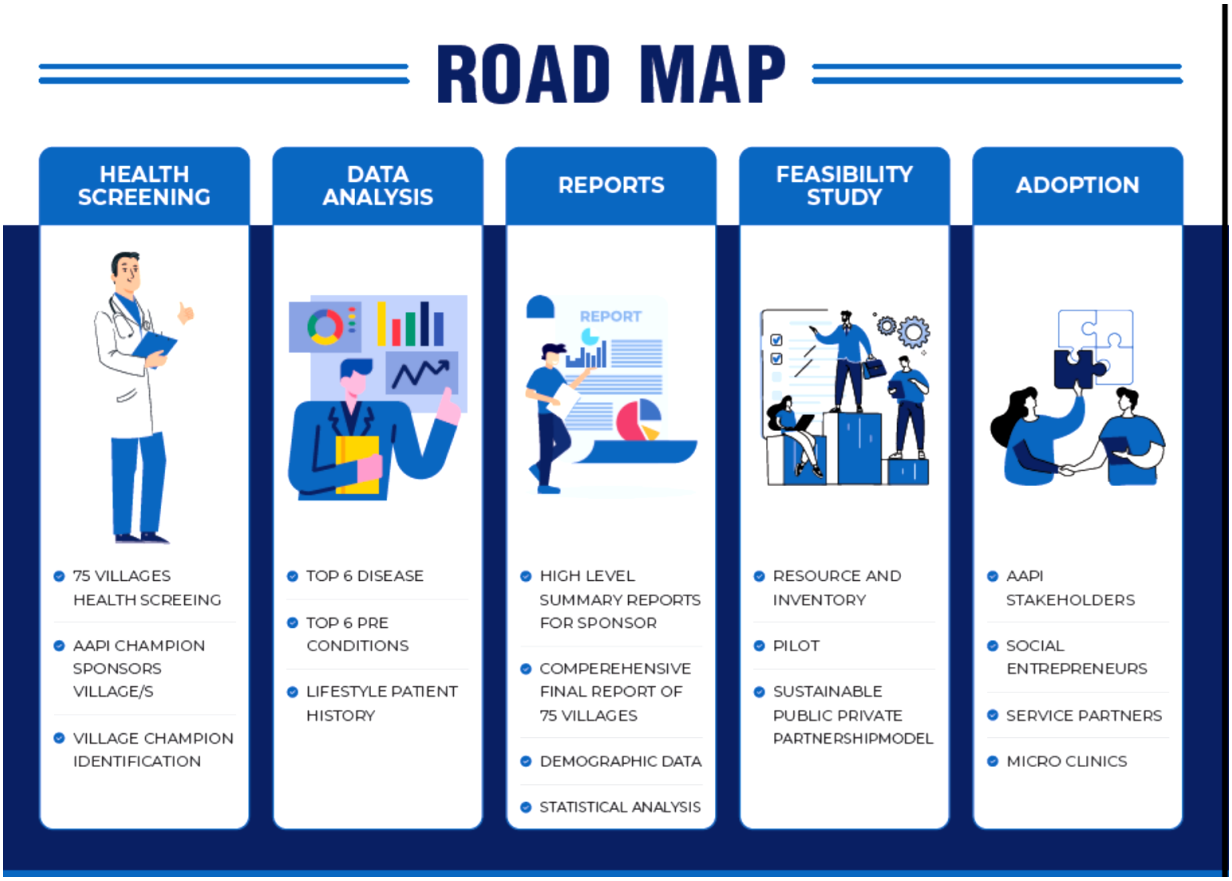


Figure 2: Roadmap of the DIPAM Project

Over a period of one to two years, we conducted health camps in 51 villages identified by sponsors (select AAPI members) and screened 5541 patients. Each donor from AAPI was provided with a report after the camp that included information about the prevalence of diseases in the area. Additionally, lab results were printed and given to the patients, who were then contacted by a GTC physician to explain the results. Based on the clinical needs of the patients, appropriate medications were recommended, and patients were advised to start medications or were guided to an appropriate medical facility or nearby primary care center for continued care. This loop of screening and consultation was part of Phase 1 of the AAPI Adopt a Village Project.

AAPI and GTC are partnering to launch the Phase 2 pilot program aimed at delivering continuity of care for patients diagnosed with NCDs. This program will focus on providing primary and preventive care for the six NCDs identified in patients screened during Phase 1.

Under Phase 2, AAPI members can select a village of their choice or sponsor one of the Phase 1 villages to participate in the pilot program. This pilot aims to assess the feasibility of implementing the DIPAM program. Over the next five years, GTC will continue to run Phase 2 for the rest of the villages that were part of Phase 1 based on the availability of funding.

GTC will hire trained medical professionals, i.e., MBBS/MD/MS physicians registered with the Medical Council of India to conduct physical examinations once a month during Phase 2. Access to GTC DIPAM Electronic Medical Records (EMR), powered by Nano Health India, will be available, and the physician will prescribe the required medications and provide a 1-month supply during the clinic visit. A daily telemedicine clinic (6 pm – 9 pm) will also be available using the Saathi app and facilitated by the village health worker hired by GTC. WhatsApp communication will also be available for villagers to communicate as needed. GTC will hire healthcare workers who will interact with the villages daily as needed and for emergencies to coordinate care with the licensed

physician. Local medical resources, such as primary healthcare centers or locally available registered medical practitioners, will be utilized for immediate care.

During Phase 2, patients diagnosed with NCDs will be evaluated by GTC-AAPI health care workers (Saathi) responsible for following up with the patients daily/weekly to monitor the effectiveness, compliance, and possible side effects of the prescribed plan of care. After the 3-month interval has been completed, the patient will have another in-person assessment by the physician and GTC-AAPI Saathi for a physical exam. SRL India labs will repeat the laboratory tests for follow-up. The patients will continue to be monitored for improvement through physical examinations and laboratory investigations at 3–6-month intervals.

All NCD-positive patients in Phase 2 will be required to implement the six pillars of lifestyle medicine into their lives. These pillars include nutrition, avoiding addictions, exercise, stress management, sleep, and maintaining social relationships (8). The program will focus on implementing these lifestyle changes into the lives of the villagers, which will lead to an economically sustainable model by charging patients the same amount as the local registered medical practitioner charges.

Statistical Methods: Descriptive statistics of cross-sectional data recorded from screening tests of six NCDs were summarized with categorical variables. Frequency counts were measured and presented as proportions (percents). The Chi-square (X^2) test of independence is the appropriate statistical method to examine if two categorical variables are independent or not. In other words, this test indicates if two variables are or are not related. The Chi-square test was used to compare NCDs across males and females and identify associations. A two-sided *P* value less than 0.05 was considered statistically significant. Since large sample sizes may increase the likelihood of a Type I error and not necessarily meaningful results, Cramer's V was used to measure the strength of statistically significant associations between NCDs and gender. Cramer's V ranges from 0 to 1 when testing associations between two dichotomous categorical variables and -1 to 1 when testing associations between categorical variables with greater than two levels. In either case, values closer to 0 indicate smaller levels of effect. These analyses will generate hypotheses and set the foundation for further categorical and longitudinal analyses in Phase 2 and Phase 3. SAS version 9.4 (SAS Institute Inc., Cary, NC) was used to perform all statistical analyses.

Results: By the end of September 2022, 5541 people were screened for six NCDs in 51 villages across five states, including Andhra Pradesh, Telangana, Gujarat, Himachal Pradesh, and Karnataka. Hypertension was the most prevalent of all the conditions, closely followed by anemia.
Age and Gender: The age of patients ranged from 4 to 100 years for females and 6 to 101 years for males. The mean age for females was 50.2 years (SD=15.2) and 53.2 years (SD=15.5) for males and the median ages were 50 years and 55 years for females and males, respectively (Figure 3). The study incorporated minors under the age of 18 who belonged to households from which data of adult participants were assessed. Our objective is to closely observe and analyze the trends of chronic diseases and health statuses during both Phase 2 and Phase 3.
A greater proportion of females were less than 30 years (56.5%) and 30 to 50 years of age (55.0%) and a greater proportion of males greater than 50 years old (55.3%) (Figure 4).

Body Mass Index (BMI): Per the Asia-Pacific Classification (APC), 44·1% of females and 38·7% of males screened were classified as obese (BMI ≥ 25), 14·3% of females and 15·57% of males were overweight (BMI of 23– 24·9), and 13·2% of females and 13·2% of men were underweight (BMI < 18·5) (Figure 5a and Figure 5b) (9).The Chi-square test indicated a significant difference in BMI among females and males (*P*<.001). The Cramer's V of 0.06 indicates a small yet, noteworthy level of association between BMI and gender. Under the WHO Classification, 15·9% of females and 10·22% of males were obese (BMI ≥ 30), 28·2% of females and 28·5% of males were overweight (BMI of 25–29·9), and 13·2% of females and 13·2% of males were underweighted (BMI < 18·5). The Chi square test also indicated a significant difference in BMI among females and males (*P* < .001) according to WHO Classification. In this case the Cramer's V of 0.09 indicates the association between BMI and gender approaching a medium level of association (Figure 6a and Figure 6b) (9).

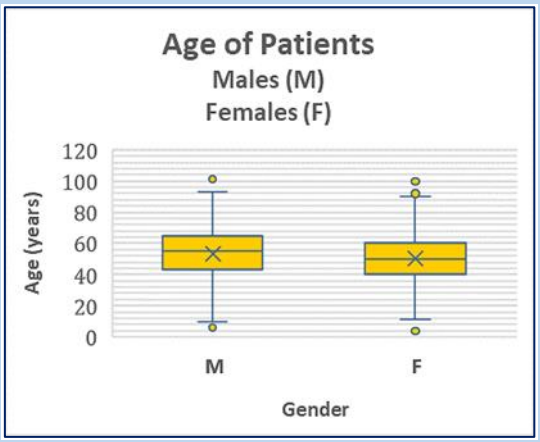


Figure 3: Age of Patients

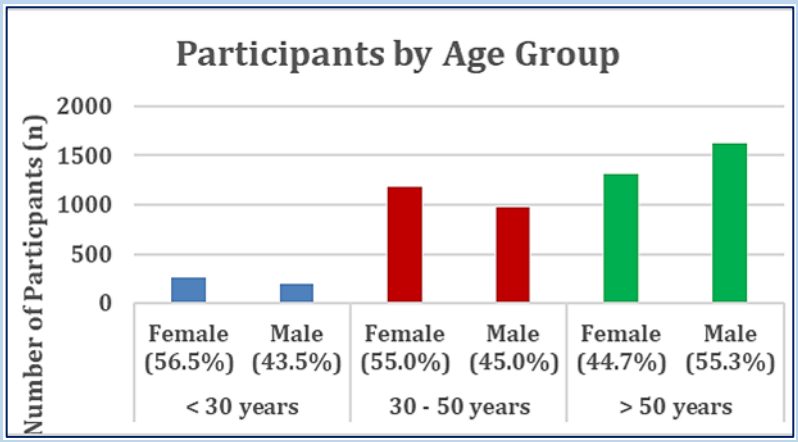


Figure 4: Participants by Age Group

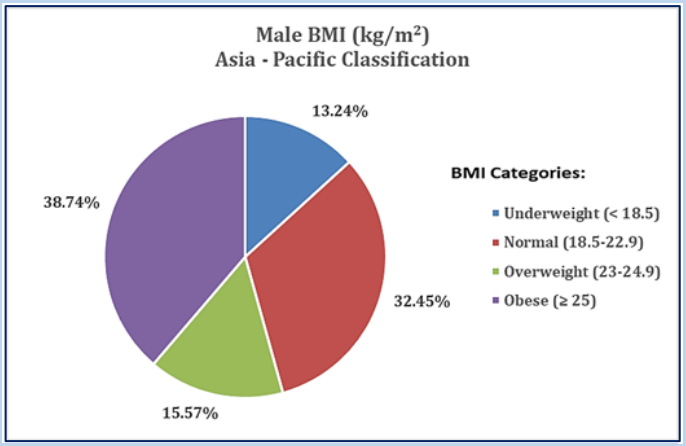


Figure 5a: BMI levels - Asia-Pacific Classification in Males

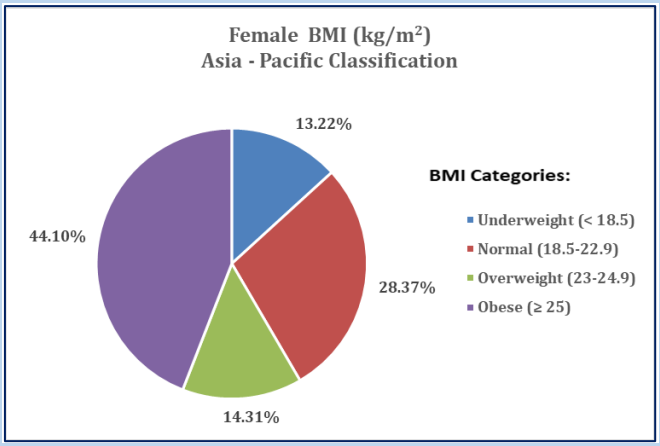


Figure 5b: BMI levels - Asia-Pacific Classification in Females

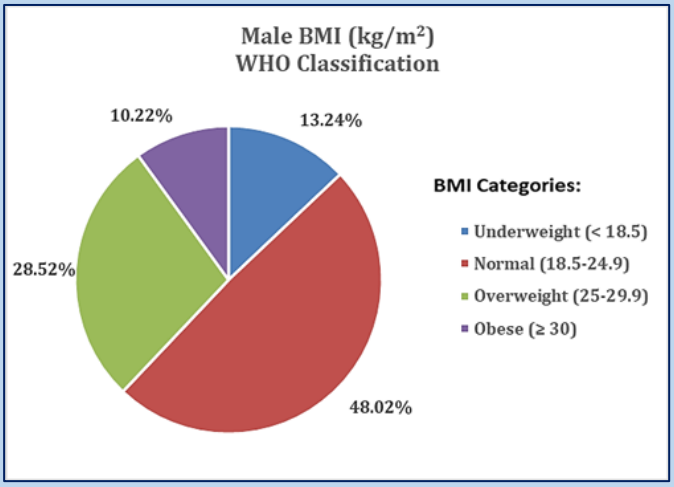


Figure 6a: BMI levels - WHO Classification

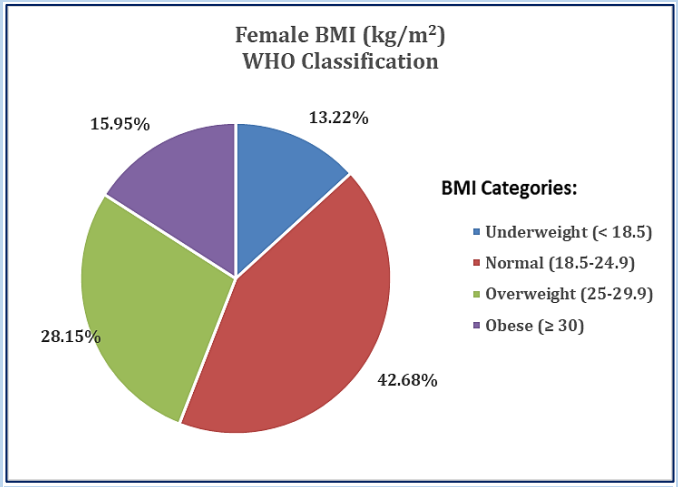


Figure 6b: BMI levels - WHO Classification

Anemia: Adhering to the WHO definition, wherein hemoglobin levels < 12 g/dl in women and < 13 g/dl in men are classified as anemia, 30·48% of females and 44·6% of males were found to be anemic (10). This notable difference in proportions across gender supported by a significant Chi-square test (*P*<.0001) and a Cramer's V of

0.015 indicating a small to medium level of association (Figure 7).

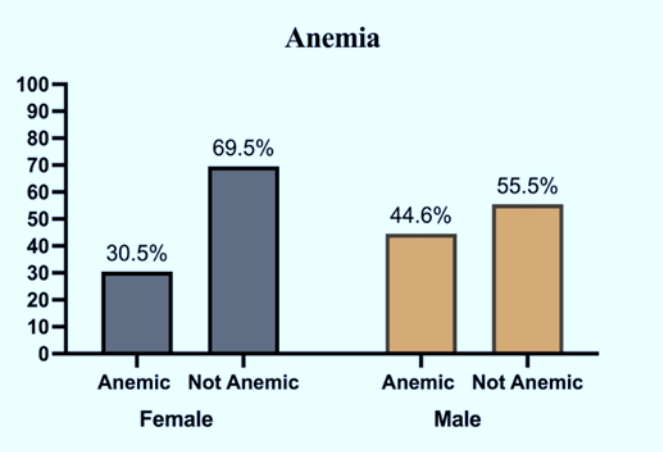


Figure 7: Anemia (Cut-off values for Hb in Male <13 g/dl; Female <12 g/dl)

Diabetes Mellitus: An HbA1c > 6·5% was used to demarcate those with diabetes mellitus. A value above 6·5% would indicate high levels of glycated hemoglobin informing us of the elevated sugar levels (11). By this cur-off point, 21·8% of women and 21·8% of men were found to have elevated levels of HbA1c. No difference in the proportion of females versus males with a HbA1c > 6.5 % was further demonstrated with the Chi-square test (*P>.05)* (Figure 8).

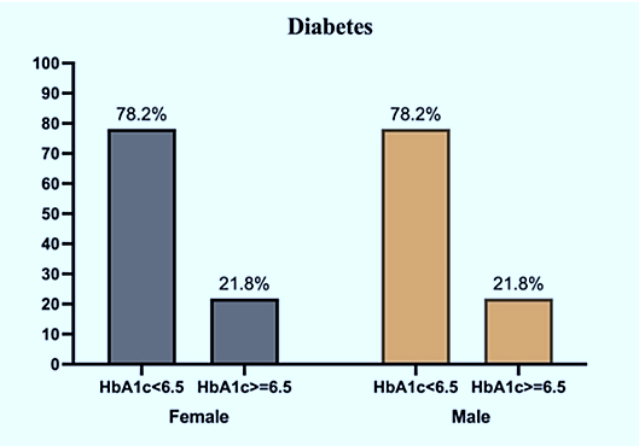


Figure 8: HbA1C Values (X-axis)

Hypertension: Systolic blood pressure (SBP) > 130 mmHg and diastolic blood pressure (DBP) > 80 mmHg readings were classified as hypertension. By this metric, 50·7% of females and 57·9% of males screened were found to be hypertensive (12). Although the Chi-square test was significant (*P*<.0001*),* the Cramer's V of -0.07 suggests a weak association between hypertension and gender (Figure 9).

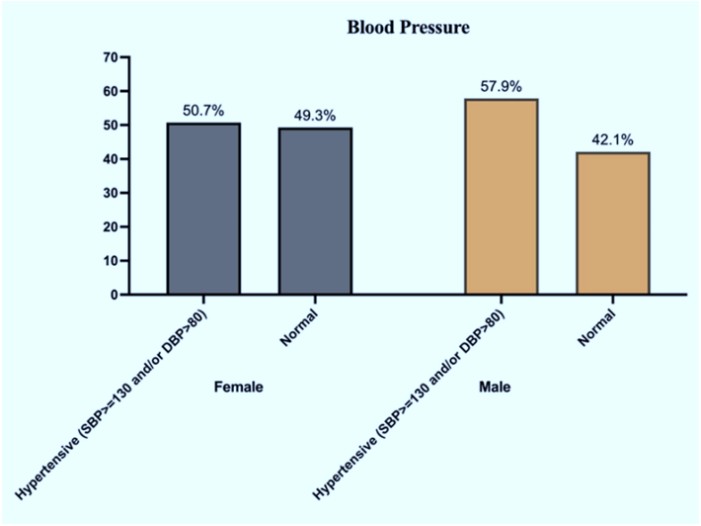


Figure 9: Blood Pressure (mmHg)

Hyperlipidemia: As defined by the Mayo Clinic, a total cholesterol (TC) level < 200 mg/dl is "normal," a TC level of 200-239 mg/dl is "borderline high," and a TC level of >240 mg/dl is "high." Of all females screened, 22·8% had borderline high, and 9·6% had high TC levels. In males, 22·9% had borderline high, and 9·3% had high TC levels (13) (Figure 9). After inputting the values into Friedewald Equation [TC - (TG/5) - HDL] for the accurate calculation of LDL-C, we found that 59·0% of females and 58·1% of males had a true elevation of LDL >100 mg/dl (14). The Chi-square test result was consistent with these observations (*P*>.05) (Figure 10).

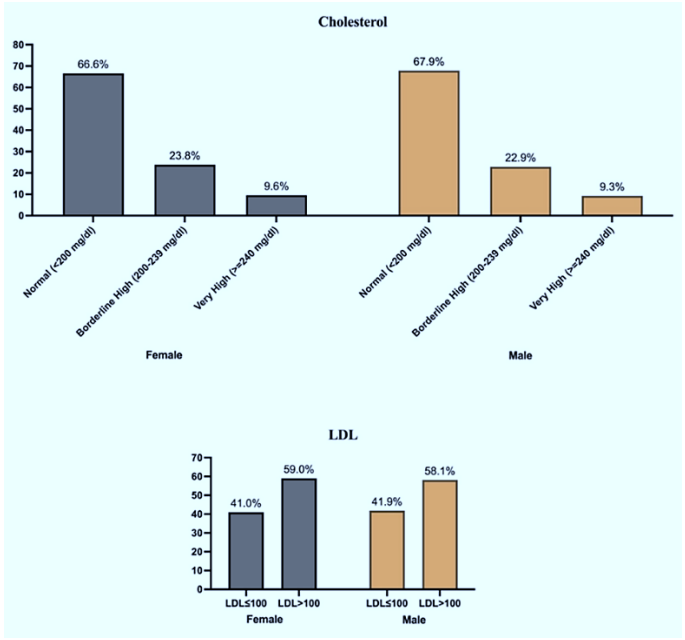


Figure 10: Total Cholesterol (mg/dl) and LDL (mg/dl)

Chronic Kidney Disease (CKD): According to the reference range provided by Mayo Clinic, the normal range of serum creatinine for men is typically 0·74 to 1·35 mg/dl, and for women, it is 0·59 to 1·04 mg/dl. We measured creatinine levels to identify any underlying kidney injury. Our results showed that 45·1% of females and 22·0% of males had elevated creatinine levels (15). These proportions are reflected in a significant Chi-square test ($P<.0001$) and indicate a moderate to strong level of association based on Cramer's V of 0.25. (Figure 11).

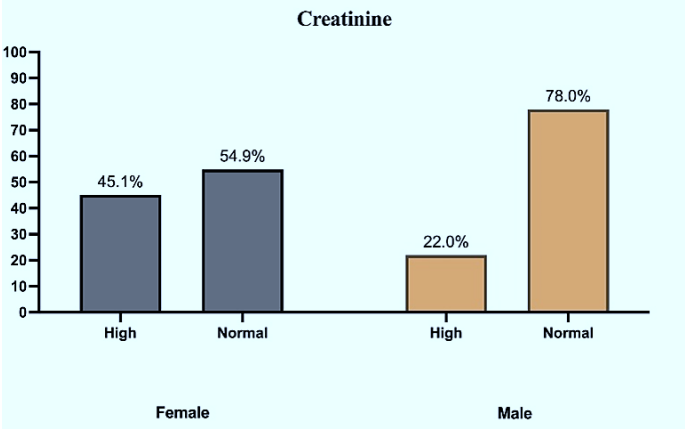


Figure 10. Serum Creatinine (mg/dl)

First Diagnosis by Age Group: The percentage of patients diagnosed for the first time with anemia remained relatively stable across the three age groups (31.0% to 35.9%). Elevated creatinine, an indicator for chronic kidney, accounted for the largest percentage of a first diagnosis for those less than 30 years old (36.8%). For those 30 to 50 years of age and greater than 50 years, an initial diagnosis of elevated creatinine increased as did obesity levels according to both the Asia-Pacific and WHO classifications. Initial diagnosis of hypertension also increased to 47.7% for those 30 to 50 years old and to 66.3% for those greater than 50 years (Figure 12).

Comorbidities: Of those diagnosed with diabetes mellitus (HbA1c ≥ 6.5%), 64.5% were also hypertensive, 51.4% were categorized as obese according to the Asia-Pacific Classification (A/P), and 33.4% were categorized as overweight according to WHO Classification. Close to 30% of those with an HbA1c ≥ 6.5% demonstrated border(line) hyperlipidemia and elevated creatinine (Figure 13).

The distributions of hypertension, elevated creatinine, border(line) hyperlipidemia, and high lipidemia were consistent across both the overweight and obese categories according to the Asia-Pacific and WHO classifications. Hypertension was the most prevalent comorbidity for those overweight or obese (57.4% to 65.1%) followed by elevated creatinine (31.2% to 36.0%) and border(line) hyperlipidemia (21.0% to 28.7%) (Figure 14).

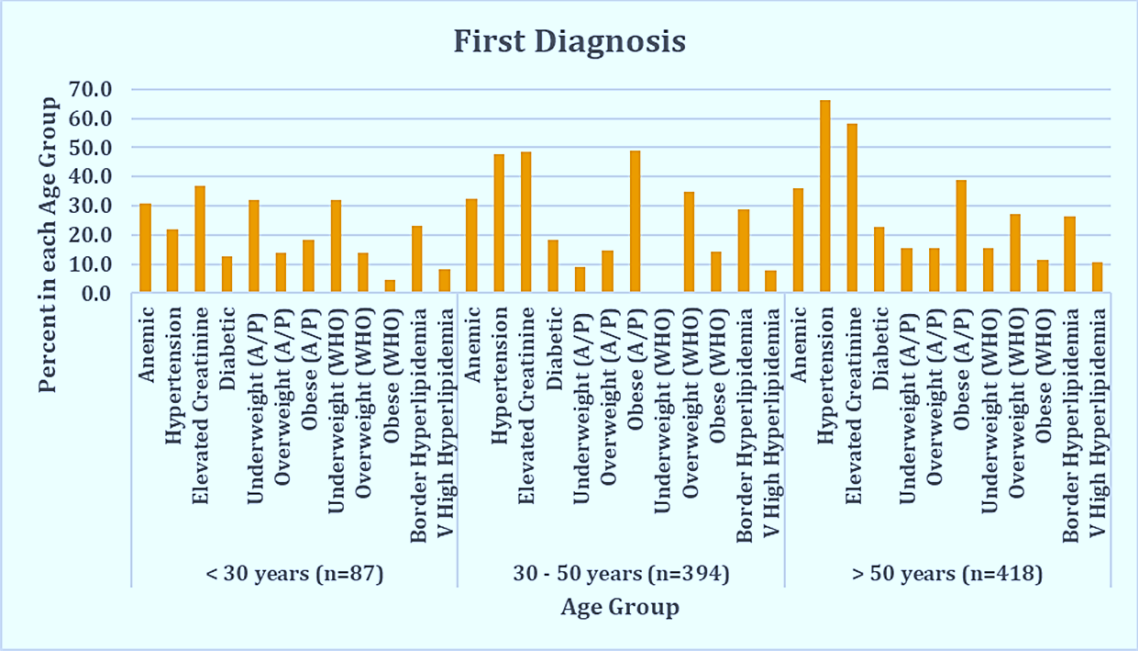


Figure 12: First Diagnosis by Age Group

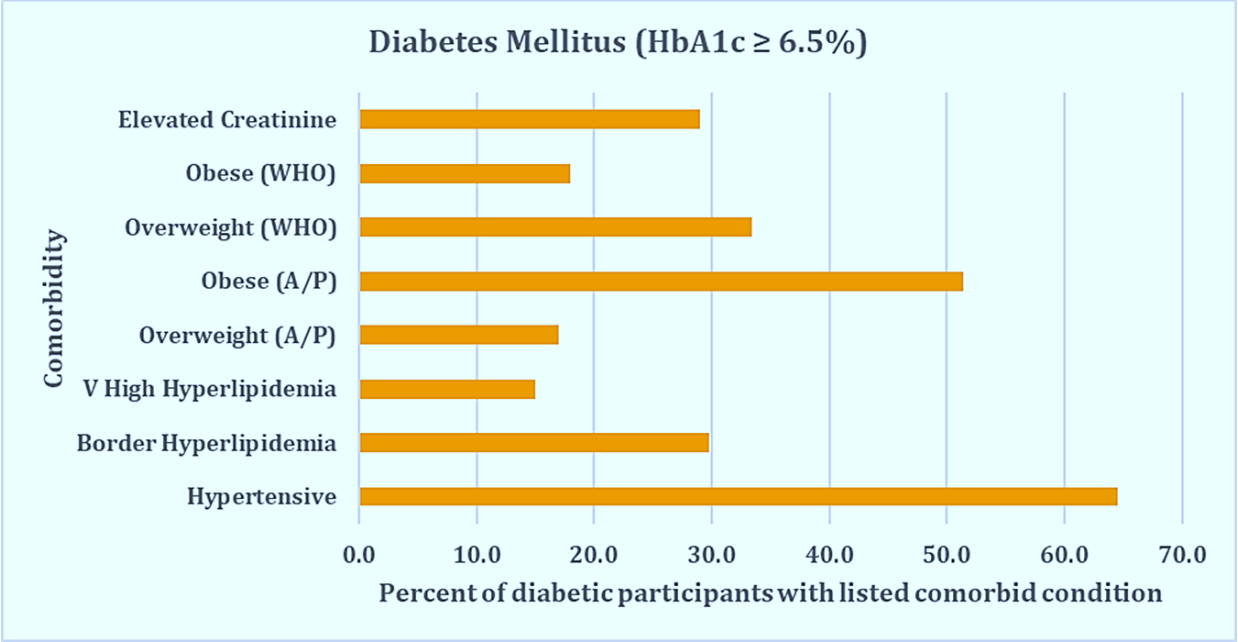


Figure 13: Comorbidities and Diabetes Mellitus (HbA1c ≥ 6.5%)

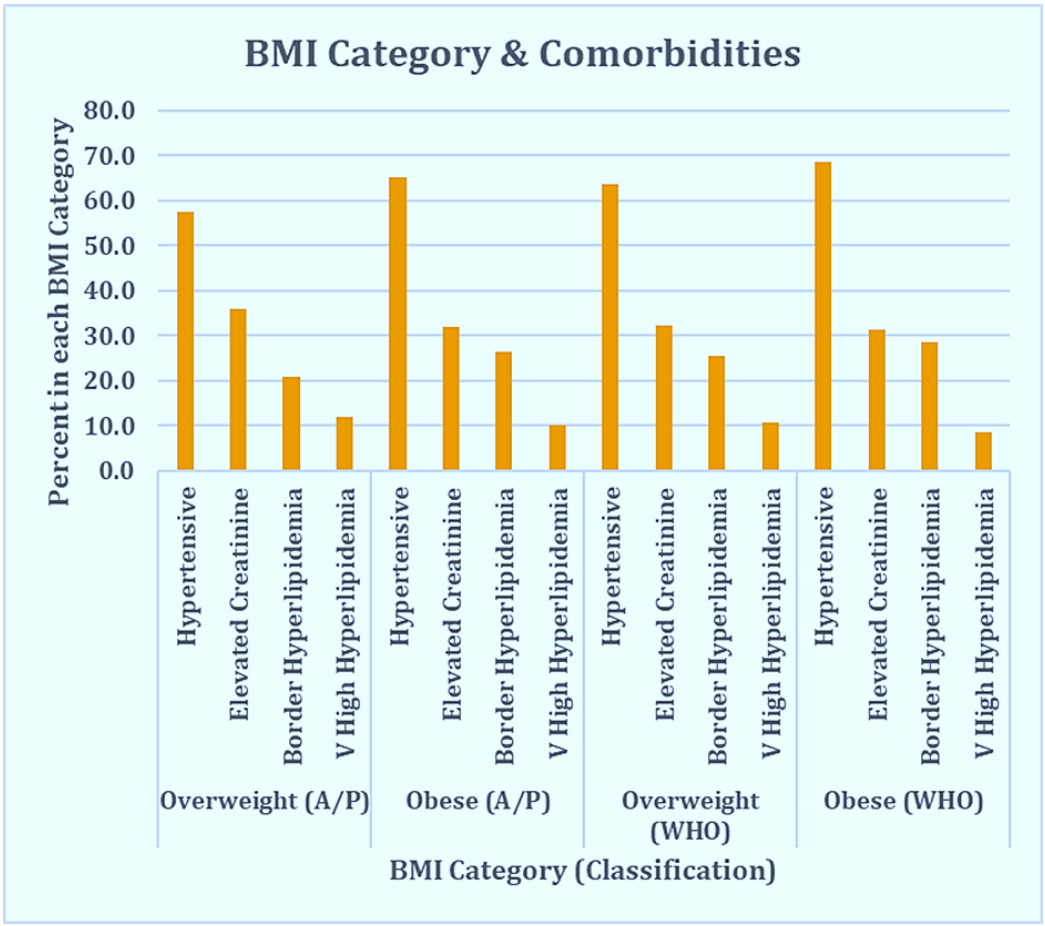


Figure 13: Comorbidities and BMI

Discussion: There has been a major epidemiological shift in the disease burden from communicable diseases to non-communicable diseases across the world. According to the WHO, NCDs have claimed approximately 41 million lives every year across the globe (16). In India, the proportion of deaths due to NCDs has almost doubled from 37·9% in 1990 to 61·8% in 2016 (16). Diseases that were predominantly observed among the wealthy urban populations are now increasingly seen in the villages of rural India (18, 19). Changes in rural lifestyles, such as nutrition, physical activity, tobacco and alcohol consumption, et cetera, are further complicated by the lack of adequate healthcare access, funding, and awareness of diseases, influencing the evolution of the epidemic of chronic diseases in these areas (20). Our study is a three-phase Digitally Integrated Prevention and Management program (DIPAM) initiated by the AAPI and executed and designed by GTC. It was established to increase the screening of non-communicable diseases and promoting a technology-assisted hybrid model for better access to prevention and management of these conditions in rural India.

Our preliminary Phase I study has focused on screening for six non-communicable diseases: obesity, diabetes mellitus, hypertension, hyperlipidemia, chronic kidney disease, and anemia. As per the Asian criteria for obesity classification, our analysis demonstrates that 44·1% of women and 38·7% of men are categorized as obese. In low and middle-income countries, the rapid economic growth and urbanization of rural areas have significantly influenced lifestyle and dietary modifications resulting in a switch from morbidity and mortality due to infectious diseases to more complicated illnesses requiring long-term care (21). According to the NFHS data, in rural areas, the prevalence of obesity almost doubled in a decade, escalating significantly from 8·6% in females and 7·3% in males during the 2005–2006 census to 15% in females and 14·3% in males in the 2015–2016 data (22). Being overweight or obese are major risk factors associated with the development of some of the most common NCDs like type 2 diabetes mellitus, hypertension, coronary heart disease, and even some cancers.

Diabetes is one of the major health problems with an increasing prevalence across the world due to changing lifestyles. India is the most populous countries in the world and has the second-largest diabetic population. In 2019, it was determined that 8·9% of India's population (77 million) were diabetic by the International Diabetes Foundation. The data from our study on the rural population suggest that a proportion of 21·83% of women and 21·84% of men were diabetic (HbA1c >6·5%). A pooled statewide diabetes prevalence analysis over the last three decades revealed that it rose from a 2·4–5·8% range during 1990–1999 to 2·4% to 17·4% during 2010–2019 (23). Swaminathan et al (24) in their study of a farming village in Tamil Nadu reported that rural areas have a higher prevalence of pre-diabetes compared to urban areas. This shift displaying a greater prevalence in rural areas is likely due to urbanization, which, along with positive development in the villages, also caused significant changes in dietary habits, including an increase in the consumption of fried food and junk food in rural areas (24).

According to the latest guidelines of the American Heart Association (AHA), we categorize patients as hypertensive when the systolic and diastolic blood pressures are consistently above 130 mmHg and/or 80 mmHg, respectively. Elevated blood pressure or hypertension is a leading cause of cardiovascular diseases and increased mortality rates. In our study, we found 50·7% of the females and 57·9% of the males were hypertensive, indicating that it affected more than half of our target population. Many people are unaware that this disease tends to progress with no warning signs or symptoms. It is prudent to note that hypertension can develop with other comorbid conditions like obesity, diabetes mellitus, and dyslipidemia with incidentally similar risk factors like unhealthy diets, reduced physical activity, and an increase in tobacco and alcohol use. A study conducted by Boro and Banerjee reported a higher prevalence of 12·4% in undiagnosed and 1·7% untreated hypertension in rural areas compared to urban areas where there were more undertreated cases (by 7·2%). These data suggest that the contributions of risk factors in the development of hypertension are further compounded by the lack of access to regular health care in rural areas (25-28).

Upon performing a screening lipid profile as part of our patient evaluation, we report that the total cholesterol was determined to be borderline high in 22·8% of the women and 22·9% of the men, and high in 9·6% in women and 9·3% in men, while 59·0% of the women and 58·1% men were determined to have a true elevation of LDL (>100 mg/dl). Total cholesterol includes HDL, LDL, and other lipid components, and elevated LDL is one of the common lipid

abnormalities. In the ICMR INDIAB study, the analysis revealed that 13·9% had hypercholesterolemia and 11·8% of the population had high LDL-C. Although there were no urban-rural differences, the common elements that contributed to the development of hyperlipidemia in both urban and rural areas are the female sex, sedentary lifestyle, and other comorbid conditions like diabetes and hypertension (29). These factors likely affected our study's target population, leading to an increase in the number of hyperlipidemia cases.

Chronic kidney disease (CKD) is one of the leading non-communicable diseases predominantly caused by diabetes and hypertension. It can develop because of persistent long-term kidney injury caused by conditions like diabetes, hypertension, and repeated infections. Although the data from our study showed that a higher proportion of elevated creatinine levels was found in females (45·1%) compared to males (22·0%), we must consider that their baseline levels were not available to us for our assessment. There could be other factors (like dehydration, increased physical activity, infections, acute kidney injury, measurement errors, laboratory cut-off ranges, et cetera) that can cause an increase in creatinine levels. These individuals were, therefore, recommended to follow up with primary care physicians for further evaluation during Phase 2. Previous studies have reported a higher prevalence of CKD in women than men, which could be explained by a greater life expectancy, increased likelihood of repeated urinary tract infections, over-diagnosis of CKD, reduced access to health care, et cetera. Although the evaluation of the exact cause for the prominent difference in prevalence is much more complex, physicians must take great care in reducing overdiagnosis and overtreatment of chronic kidney disease (30-32).

In our study, we found that 30·5% (<12 g/dl) of the women and 44·6% (13g/dl) of men were anemic. The cause for anemia can be multifactorial, viz., iron deficiency, B12 deficiency, folic acid deficiency, helminthic infections, genetic causes, et cetera. The most common causes of anemia are nutritional deficiencies. Previous studies have shown a high prevalence of iron deficiency anemia in Indian women. This is an important factor to consider when we determine its implications on the maternal mortality rate. To reduce nutritional deficiencies and the maternal mortality rate caused by them, it is essential to implement good preventive care programs (33). Other nutritional deficiencies are common in people from rural India due to a vegetarian diet, which results in the reduced bioavailability of vitamin B12. Although a vegetarian diet does not necessarily represent an inadequate diet, it is essential that we supplement appropriately with vitamin B12 to ensure the prevention of deficiencies (34).

A major strength of the study is that, to the best of our knowledge, this is one of the first to test the feasibility of a hybrid model of care using a licensed medical practitioner and digital platform to provide healthcare for people in rural areas. One of the study's limitations is that the representative study samples are from villages selected based on the preferences of the sponsors. This could affect the generalizability of the study. Additionally, due to limitations in funding, we could not provide continuous care during phase 1 of the study.

Future Considerations and Sustainability: In Phase 2, our initiative transitions from identifying chronic diseases to implementing comprehensive care strategies tailored to address them. We select specific villages for focused intervention, conducting regular in-person examinations and integrating telemedicine services to ensure continuous access to healthcare. This phase emphasizes the importance of proactive management and early intervention, with dedicated healthcare workers playing a crucial role in facilitating patient-doctor interactions and promoting adherence to treatment plans. By nurturing strong communication channels and leveraging technology, Phase 2 aims to lay the groundwork for sustainable healthcare delivery while addressing the immediate needs of identified populations.

Phase 3 represents a transformative shift towards community engagement and long-term sustainability. Building upon the successes and insights gained from earlier phases, we forge partnerships with public enterprises to establish a fee-based, low-cost model for healthcare consultations. This collaborative approach not only enhances accessibility but also ensures financial viability, enabling us to expand our reach and impact. By integrating local healthcare providers and leveraging lifestyle medicine principles, Phase 3 aims to empower individuals to take ownership of their health while addressing the root causes of chronic diseases. Through education, prevention, and holistic management strategies, we seek to create a lasting legacy of improved

health outcomes and enhanced well-being within rural communities.

By providing a more nuanced depiction of Phase 2 and Phase 3, we can better convey the depth and significance of our ongoing efforts to revolutionize healthcare delivery and promote sustainable change. The Hybrid clinic process involves telemedicine and in person visits and we named it as DIGITAL INTEGRATED PREVENTION AND MANAGEMENT PROGRAM(DIPAM): Which in Telugu language signifies light: Bringing light through healing hands. Please see below for the clinic process (Figure 15).

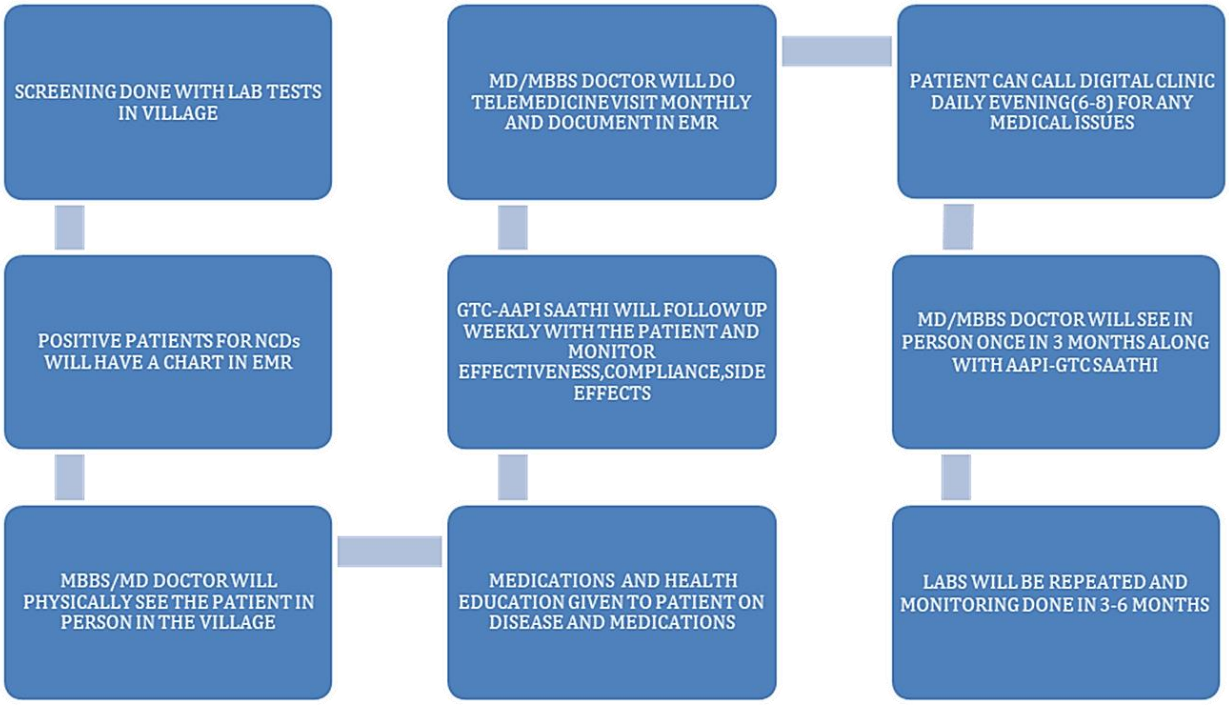


Figure 15: Digital Integrated Prevention and Management Program (DIPAM)

Conclusion: This study evaluated the feasibility of a hybrid healthcare delivery model and identified gaps and concerns in providing efficient patient care. It also showed that by leveraging a public-private partnership, primary care can be delivered through a combination of digital platforms and in-person, which is potentially the future of healthcare. Furthermore, this model allows for the introduction and implementation of lifestyle modifications for rural patients, which could reverse chronic diseases. This study is of considerable significance as it endeavors to establish a groundbreaking healthcare delivery approach in hard-to-reach, rural communities, which has not been previously explored. In addition, there is a pressing need for the development of annual preventive check-up guidelines tailored toward rural populations and their unique healthcare needs. Due to the challenges of accessing healthcare in remote areas, many rural residents may not receive regular checkups and preventive care. This can lead to undiagnosed health issues and a higher risk of chronic diseases. By tailoring guidelines and promoting regular checkups for rural populations, healthcare providers can help identify health concerns early and implement appropriate interventions. This is particularly important given the higher rates of chronic diseases, such as obesity and diabetes, in rural areas. By improving access to preventive care and addressing the unique health needs of rural populations, this hybrid healthcare delivery model has the potential to improve health outcomes and reduce healthcare disparities. It is imperative that we create Indian Preventive Services Task Force guidelines (IPSTF) based on evidence similar to the United States Preventive Services Task Force (USPSTF) guidelines to help clinicians and

healthcare providers implement preventive strategies and improve the overall health of the rural Indian communities.

Disclosure: The initiative was sponsored by 51 AAPI members, including Murthy Gokula, the coauthor of the study. All other authors report no competing interests.

Authors Contributions: Gokula M was involved in the concept and design of the study and data acquisition. Gandrakota N and Kennedy M contributed to the analysis and interpretation of the data. Ramakrishnan M, Vanamada C S, Kiran V, Nair S, and Sudireddy K drafted the manuscript. Critical revision of the manuscript for important intellectual content was done by Murthy P, Gokula M, Gandrakota N, and Ramakrishnan M. Administrative, technical, or material support was provided by Gokula M; Supervision by Gandrakota N.

Acknowledgments: This project was approved by the AAPI Executive Committee. Funding for this project was provided by AAPI members who sponsored their villages of choice. Two of the sponsors, Gokula M, and Kathula S, developed the concept of the study. Gokula M contributed to the study's design and data acquisition. They were not involved in the analysis or interpretation of data; in the writing of the report; and in the decision to submit the paper for publication. Authors appreciate the expertise, and support offered by Drs. Anupama Gotimukula, Ravi Kolli, Bharath Bhikhubhai Champaneria, Rao Movva, and Anuradha Mann.

Data Sharing: The data used in this study are available to the journal's peer reviewers and legitimate interested parties, to enable them to evaluate the study's findings. Data will be in a deidentified form to protect participant privacy. Any restrictions on data access will be disclosed to potential reviewers.

References:

1. Ezzati M, Pearson-Stuttard J, Bennett J, et al. Acting on non-communicable diseases in low- and middle-income tropical countries. *Nature* 559:507–516, 2018. https://doi.org/10.1038/s41586-018-0306-9

2. Global Noncommunicable Diseases | Global Health | CDC [Internet]. Available from: https://www.cdc.gov/globalhealth/healthprotection/ncd/index.html

3. Thakur J, Paika R, Singh S. Burden of noncommunicable diseases and implementation challenges of National NCD Programmes in India. *Med J Armed Forces India* 76:261-267, 2020 https://doi.org/10.1016/j.mjafi.2020.03.002

4. Catoe H, Jarvis J, Gupta S, et al. The Road to Addressing Noncommunicable Diseases and Cancer in Global Health Policy. ASCO Educ Book. 2017 May; 37:29-33. https://doi.org/10.1200/EDBK_100012

5. Malta D, Bernal R, Lima M, et al. Socioeconomic inequalities related to noncommunicable diseases and their limitations: National Health Survey, 2019. *Rev Bras Epidemiol* 2021; 24(suppl.2):e210011.supp.2. https://doi.org/10.1590/1980-549720210011.supl.2

6. Bennett JE, Kontis V, Mathers CD, et al. NCD Countdown 2030: Pathways to achieving Sustainable Development Goal target 3.4. *Lancet* 396:918-34, 2020 DOI:https://doi.org/10.1016/S0140-6736(20)31761-X

7. Targets of Sustainable Development Goal 3 [Internet]. Available from: https://www.who.int/europe/about-us/our-work/sustainable-development-goals/targets-of-sustainable-development-goal-3

8. American College of Lifestyle Medicine: Home [Internet]. Available from: https://lifestylemedicine.org/

9. Lim JU, Lee JH, Kim JS, et al. Comparison of World Health Organization and Asia-Pacific body mass index classifications in COPD patients. *Int J Chron Obstruct Pulmon Dis* 12:2465-2475, 2017 https://doi.org/10.2147/COPD.S141295

10. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. Available from: https://apps.who.int/iris/bitstream/handle/10665/85839/WHO_NMH_NHD_MNM_11.1_eng.pdf

11. International Expert Committee. International Expert Committee report on the role of the A1c assay in the diagnosis of diabetes. *Diabetes Care* 32:1327-34, 2009

12. Understanding Blood Pressure Readings | American Heart Association. Available from: https://www.heart.org/en/health-topics/high-blood-pressure/understanding-blood-pressure-readings

13. High cholesterol - Diagnosis and treatment - Mayo Clinic. Available from May Clinic: https://www.mayoclinic.org/diseases-conditions/high-blood-cholesterol/diagnosis-treatment/drc-20350806

14. Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. *Clin Chem* 18:499-502, 1972

15. Creatinine test - Mayo Clinic. Available from: https://www.mayoclinic.org/tests-procedures/creatinine-test/about/pac-20384646

16. Non-communicable diseases. Available from the World Health Organization: https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases

17. Status of Non-Communicable Diseases (NCDs) in India. Available from the Government of India: https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1796435

18. Kumar R, Kumar D, Jagnoor J, et al. Epidemiological transition in a rural community of northern India: 18-year mortality surveillance using verbal autopsy. *J Epidemiol Community Health* 66:890-893, 2012 https://doi.org/10·1136/jech-2011-200336

19. Joshi R, Cardona M, Iyengar S, et al. Chronic diseases now a leading cause of death in rural India--mortality data from the Andhra Pradesh Rural Health Initiative. *Int J Epidemiol* 35:1522-1526, 2006 https://doi.org/10·1093/ije/dyl168

20. Nath A, Shalini MA, Mathur P. Health systems challenges and opportunities in tackling non-communicable diseases in rural areas of India. *Natl Med J India* 34:29-35, 2021 doi: 10.4103/0970-258X.323661.

21. INDIA FACT SHEET R 10 FINAL.indd, Available from: http://rchiips.org/nfhs/pdf/nfhs4/india.pdf

22. Aiyar A, Rahman A, Pingali P. India's rural transformation and rising obesity burden. *World Development* 2021 May;138:105258. doi:10.1016/j.worlddev.2020.105258

23. Ranasinghe P, Jayawardena R, Gamage N, et al. Prevalence and trends of the diabetes epidemic in urban and rural India: A pooled systematic review and meta-analysis of 1·7 million adults. *Ann Epidemiol* 58:128-148, 2021. doi: 10.1016/j.annepidem.2021.02.016.

24. Swaminathan K, Veerasekar G, Kuppusamy et al. Noncommunicable disease in rural India: Are we seriously underestimating the risk? The Nallampatti noncommunicable disease study. *Indian J Endocrinol Metab* 21:90-95, 2017. Doi: 10.4103/2230-8210.196001.

25. Vijna, Mishra CP. Prevalence and predictors of hypertension: Evidence from a study of rural India. *J Family Med Prim Care* 11:1047-1054, 2022 doi: 10.4103/jfmpc.jfmpc_967_21.

26. Schmieder RE, Ruilope LM. Blood pressure control in patients with comorbidities. *J Clin Hypertens (Greenwich)* 10:624-631, 2008 doi: 10.1111/j.1751-7176.2008.08172.x.

27. World Health Organization. Hypertension. Updated August 25, 2021. https://www.who.int/news-room/fact-sheets/detail/hypertension

28. Boro B, Banerjee S. Decomposing the rural–urban gap in the prevalence of undiagnosed, untreated and under-treated hypertension among older adults in India. *BMC Public Health* 2022 Jun;22(1):1310. doi: 10.1186/s12889-022-13664-1.

29. Joshi SR, Anjana RM, Deepa M, et al. Prevalence of dyslipidemia in urban and rural India: the ICMR-INDIAB study. *PLoS One* 2014 May 9;9(5):e96808. doi: 10.1371/journal.p

30. Olanrewaju TO, Aderibigbe A, Popoola A, et al. Prevalence of chronic kidney disease and risk factors in North-Central Nigeria: a population-based survey. *BMC Nephrology* 21(1), 467, 2020 https://doi.org/10.1186/s12882-020-02126-8

31. Lewandowski MJ, Rottenkolber M, Prischl FC, et al. Chronic kidney disease is more prevalent among women but more men than women are under nephrological care. *Wiener klinische Wochenschrift* 1-8, 2020 https://doi.org/10.1007/s00508-022-02074-3

32. Moynihan R, Glassock R, Doust J. Chronic kidney disease controversy: how expanding definitions are unnecessarily labelling many people as diseased. *BMJ* 347, f4298, 2013 https://doi.org/10.1136/bmj.f4298

33. Alvarez-Uria G, Naik PK, Midde et al. Prevalence and severity of anaemia stratified by age and gender in rural India. *Anemia* 2014, 176182, 2014 https://doi.org/10.1155/2014/176182

34. Bhardwaj A, Kumar D Raina, SK, et al. Rapid assessment for coexistence of vitamin B12 and iron deficiency anemia among adolescent males and females in Northern Himalayan state of India. Anemia 2013, 959605. https://doi.org/10.1155/2013/959605