

Occurrence of Metabolic Diseases among Apparently Fit Adult Population in Pakistan: An Organized Survey and Meta-Analysis

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Abstract

Aim: This study aims to determine the prevalence of metabolic diseases in ostensibly healthy adults living in Pakistan, focusing on disease specific and associated risk factors while correlating lifestyle/ dietary habits with markers of metabolic health.

Methods: We undertook a systematic review and meta-analysis of primary studies encapsulated within national health surveys. Adults meeting fitness criteria were eligible, and exclusion criteria included the following health conditions. The sampling methods were conducted to obtain representative global samples from diverse geographic regions, allowed for statistical meta-analysis and subgroup analyses.

Results: The results show a high prevalence of metabolic disease in the studied sample in apparently fit adults to Pakistan, including type 2 diabetes mellitus (type Dimi), hypertension and dyslipidaemia with obesity. We found a variation in prevalence among urban and rural areas, due to socioeconomic disparities and genetic risk factors. Lifestyle traits (dietaries, physical activity), as well economic status where the next Category III clusters showed a significant effect on metabolic health.

Keywords: Metabolic Diseases, Health Interventions, Prevalence, Risk Factors.

Introduction

Background Information

Metabolic diseases are the range of health disorders that occur when some aspect of normal metabolism goes awry, disrupting an organism's ability to carry out essential life functions. These include type 2 diabetes mellitus, hypertension and its corollary of end-organ damage such as stroke, dyslipidaemia

leading to heart disease (or cerebrovascular accident), obesity which predisposes the individual to several other chronic diseases that affect both individuals and healthcare systems everywhere. Metabolic diseases essentially result from the complex interplay between genetic predispositions and environmental factors, especially lifestyle habits including diet and exercise. This contributes to a significant public health problem that is endemic, they are complications of chronic nature and consumption of healthcare resources [1].

There is an increasing need to understand the prevalence and implications of metabolic disease also in apparently fit adults particularly important context as Pakistan where large-scale urbanisation has shifted populations towards more westernised diets, which may contribute to changing profiles of diseases. Put another way, what this means is that a seemingly healthy and physically active adult who would be deemed "fit" based on traditional measures may have the unwitting beginnings of disease (stage 2 or even stage 3) without any evidence of clinical symptoms. This paradoxical situation emphasizes the need for focused research to identify hidden metabolic defects and prevent them from becoming more severe.

Research Objectives

This study proposal has diverse primary objectives which are detailed as follows; i) To flesh out the metabolic landscape among seemingly normal adults in Pakistan with respect to non-communicable diseases (NCDs). To measure the burden of metabolic diseases: as there has been an obesity epidemic all over, we need to know about how many adults classified according to physical appearance and self-reported health status might be free from

diabetes mellitus (DM), hypertension (HTN), dyslipidaemia or obese. This study is looking at hidden burdens of disease within this group by surveying and meta-analysing prevalence rates. List some common metabolic diseases along with their risk factors among apparently fit adults-to better describe than simply the magnitude of the problem (prevalence) These factors may include genetic predisposition, dietary habits of individuals, physical inactivity for most part based on the socioeconomic status, and other lifestyle behaviours which are very common among Pakistani population.

For assessing the lifestyle and eating habits as determinant: Lifestyle is considered to be one of important factor in relation with increasing prevalence of metabolic diseases. The study will investigate the dietary and activity patterns as well as sedentary behaviour among apparently healthy adults in Pakistan on factors associated with metabolic health outcomes. This synthesis is essential for the development of effective targeted interventions and public health strategies to prevent or manage these influences [2].

Importance of the current investigation is that it may guide toward developing targeted strategies to combat metabolic health issues among metabolically healthy out-wardly fit adults in Pakistan. This study seeks to provide information on what diseases are happening widely or not as well, how risky factors work in these circumstances and their effect so that this exploration will influence all health disparities characterized populations until now through such way. These findings will provide necessary insight for policy makers and clinicians working towards controlling metabolic diseases in Pakistan, as well other countries facing similar burden of disease.

Literature Review

Morbidity of Metabolic Diseases

Metabolic diseases are one of the major health concerns throughout the world and include multifaceted disorders which affect metabolic systems. These diseases, such as type 2 diabetes mellitus (T2DM), hypertension, dyslipidaemia and obesity have become major health problems worldwide with common genetic factors predisposing to both insulin resistance and atherosclerosis risk. The worldwide

incidence of metabolic diseases reflects worrisome trends, as rates have been on the rise for which it has worsened over past several decennia. As per the global health reports, along with epidemiological studies to provide an overview of variation in burden of diseases by region as a result from demographic change and economic development continues such as ageing populations urbanization dietary changes varying healthcare infrastructures etc. Sex C. Metabolic Health in Humans with Preserved Fitness

Apparently healthy adult refers to individuals who by outward appearance and self-report of health status, may not show overt signs or symptoms indicative of illness. A large proportion of this population have underlying metabolic health that is hidden behind a lack of symptoms or visible illness, meaning the true risk due to COVID-19 maybe underestimated. Results from past investigations indicate a paradoxical relationship between health status and metabolic dysfunction, suggesting that more sophisticated methods to evaluate and address the issue of poor cardiometabolic outcomes in metabolically healthy women are required.

Recent research investigating metabolic health status of metabolically healthy adults revealed that a holistic approach to screening and risk assessment, beyond conventional markers for chronic diseases alone is warranted. Those reports are rife with the discovery of previously unseen metabolic diseases and risk factors, proving that health is decidedly not skin deep. The study concludes that understanding metabolic health in apparently healthy adults necessitates the use of a comprehensive array of biomarkers, imaging modalities and bio measurements linked together to identify potential early disease endotypes will allow for better prediction scores and treatment approaches [3].

Risk Factors and Contributors C.

Genetic predisposition: Genetic factors have a key role in the origin of metabolic diseases due to its influences. The diversity in the genetic aspects associated with glucose metabolism, lipid metabolism and insulin sensitivity contribute significantly to an individual being more at-risk of such conditions as diabetics or

dyslipidaemia for instance. We highlight the genetic underpinnings of metabolic risk profiles in seemingly healthy adults and its interaction with environmental factors.

Lifestyle Factors (diet, physical activity): Lifestyle contributes either negatively or positively on the metabolic healthier. Interestingly, the intake of diets rich in refined sugars and saturated fats (such as another fast-food diet) promotes insulin resistance through dyslipidaemia which a predisposing factor for metabolic diseases. By contrast, exercising regularly-particularly both aerobic exercise and resistance training-is known to enhance insulin sensitivity levels while improving lipid profiles and full metabolic function. Is to understand the dietary habits and sedentary lifestyle of Pakistani culture because these are all risk factors that we may adjust according to local population.

Figure 1: Factors like Socioeconomic status (SES) hugely contributes to the prevailing burden and control of metabolic diseases. The results of this strategy combined with the lack of affordable choices often lead to higher percentage rates for obesity, diabetes, and hypertension in populations with lower SES due to limited access by means food (19), healthcare resources(20) and physical exertion facilities 21]. This leads to health disparities, socio-economic and environmental impacts manifesting in both urban as well as rural parts of Pakistan [5]. Closing the gap between population subgroups will require broad community and public health initiatives that ensure all Mississippians have access to quality healthcare, education on healthy lifestyle choices, as well as economic development opportunities.

In conclusion, the epidemiology of metabolic disorders even in apparently healthy adult individual from Pakistan and around the globe represents a very complex interaction between genetic predisposition, life-style related factors and socio-economic determinants. An array of complex precision scientific studies will be necessary for a comprehensive understanding in order to develop beneficial interventions and policies towards good health outcomes that include metabolic well-being even among the apparently fit populations. This review

provides a framework for understanding the epidemiology of metabolic disease in fit looking adults with well established risk factors, as it highlights an important and yet largely neglected area that requires novel integrated strategies to help identify those at increased NIH prediction scores allowing intervention [4].

Methodology

Study Design

The objective of this study is to determine the proportion and predictors for having metabolic diseases in metabolically healthy appearing individuals using mixed method approach of survey methodology plus meta-analysis among Pakistani adults. In two parts, the survey part is where data are collected directly from participants and meta-analysis involves aggregating results of existing research to form an overall understanding.

Methods Questionnaire Based Survey and Meta-Analysis: This survey is designed to collect primary data about the status of metabolic diseases, risk factors for these conditions (like blood pressure) as well as lifestyle behaviours in adults 45 years old age or more purportedly free from any chronic disease. Validated questionnaires and clinical assessments to determine their metabolic health status will be used. At the same time, meta-analysis will provide a systematic review of existing literature and pool data from relevant studies to give quantitative estimates of prevalence across various populations and settings.

Rationale for Selected Methodology: A survey allows us to work with floppy individuals, collecting detailed information on health from a human participant and ensures that we are obtaining relevant data which is associated with the daily lifestyle of residence being considered. The technique makes it possible to identify aspects of specific metabolic diseases that might not be recognizable within a group apparently free of disease, and thus provides both unique insights into the risk profiles underlying health disparities in human populations, as well as greater information on the relative importance with which different factors (behaviours or pharmacologic

treatments) contribute towards reductions in overall mortality.

A meta-analysis extends the popularity survey by aggregating results across these diverse sources, strengthening and broadening appeal of a study. Although meta-analyses allow to obtain more generalizable estimates of the prevalence and determinants (and even trends) accompanied by possible biases/vast heterogeneity across study designs/populations within age groups [5].

Selection Criteria

Inclusion Criteria:

Target Age Group: Adults 18 years and over.

Fitness Criteria: Individuals reported moderately fit at baseline FEV1 (forced expiratory volume in 0.5 seconds) and negative responses to chronic diseases on a Computer Assisted Personal Interviewing questionnaire by Layne et al.

Exclusion Criteria:

Habitual consumption of non-nutritive sweeteners in individuals with diagnosed metabolic diseases or chronic conditions that impact upon markers of glucose homeostasis and/or dyslipidaemia

Patients who had any cognitive or communicative impairment which prevented them giving informed consent and participating in the survey.

Data Collection

Sampling: The study will use stratified random sampling to include participants from different demographic areas of Pakistan. Stratifications on factors, such as geographic location (urban vs. rural), socioeconomic status and age distribution within the population will be accounted for to represent differences in metabolic health indicators across different segments of populations etc. We will derive sampling frames from national health surveys and population registries to improve sample representativeness.

Data Sources:

Primary Studies: Data collected from apparently healthy adult previously in the form of direct surveys administered across selected study sites located throughout Pakistan.

National Health Surveys: Utilize national health surveys (e.g. Pakistan Demographic and Health Survey) to expand the geographic

research areas available with country-wide data on metabolic disease prevalence, access some information from this at a population level for diet risk factors

Data Analysis

Meta-Analysis Statistical Methods:

Comprehensive statistical software (e.g., R, Stata) will be used for meta-analysis to synthesis the quantitative data of primary studies. Pool studies will be meta-analysed to combine and effect sizes calculated (prevalence rates, odds ratios) using random-effects models due to anticipated between-studies heterogeneity. We plan to further explore heterogeneity through sensitivity analyses and subgroup analyses, which will examine differences by age, sex types of populations investigated (e.g., see range from individual patients diagnosed with COVID-19 confirmed cases versus unselected general population) geographic regions as well type of study design used may provide additional evidence on potential sources variability bias [6].

Consideration of Subgroup Analyses:

The Factor of Demographics: Age Based Profile, Gender Ratio, Economic Classification. Geographical Variations: Urban-rural divide and regional differences with-in Pakistan.

Quality Assessment: This section should include information on the methodological quality evaluation, sample size and diagnostic criteria of metabolic diseases.

This study is supposed to contribute in better understanding of metabolic diseases among adults who are apparently fit utilizing sound survey and meta-analysis methodologies. Through the integration of primary data with established evidence in existing literature, these collaborations are expected to inform implementation strategies and policies that will enhance metabolic health outcomes as well reduce chronic disease burden for marginalized populations.

Study Design

The purpose of this study is to provide an in-depth assessment of the prevalence and risk factors associated with metabolic disorders at apparently healthy adults from Pakistan by using a dual-method approach combining survey methodology and meta-analysis. The

survey module aims to obtain first-hand information from participants and is used for the original data collection, while meta-analysis studies synthesizing results of current investigations are mustering evidence on burden associated with metabolic diseases in such specific population.

Methods Survey and Meta-Analysis :Metabolic health status of participants will be assessed by using validated questionnaires, physical examinations and biochemical tests. Here, we measured important metabolic features including blood glucose control; a range of lipid profiles; and recorded averaged systolic/diastolic BP across 24-hours to assess whether additional CVD risk was present in apparently healthy individuals.

Meta-analysis, however, will require a systematic review and analysis of published literature on metabolic diseases in healthy adults living apparently well lifestyle from Pakistan. Meta-analysis pools data from multiple studies to estimate the burden of metabolic diseases overall and within specific subgroups, by region, and according to common risk factors for metabolic health outcomes.

Rationale for Methodologies Used: The combination of survey and meta-analysis methodologies has multiple strengths to address the research objectives we set out on this study. **Intensive Data Capture:** The survey approach allows for in-depth primary data on putatively healthy adults and details of their metabolic health along with risk factors. This is needed to understand health information in real-time and support early identification of those who may benefit from interventions and targeted healthcare [7].

Meta-analysis takes data sets from a multitude of sources (including primary studies and national health surveys) to create new evidence about the subject under investigation - this increases depth and scope in order to shed light on disparities within populations. Meta-analysis thus offers a wider view on the distribution and determinants of metabolic diseases by combining data across various studies, making comparisons between diverse populations/settings possible.

Improved Validity and Reliability: This study combined data extraction directly from original articles with the synthesis of extracted evidence, which helps alleviate some of the limitations associated with both primary studies (e.g., small sample size and methodological variability) as well as reviews. This not only increases the validity and reliability of study findings but also provides a thorough assessment based on consistency, whole computation additionally avoids random error.

Selection Criteria

Inclusion Criteria:

Age: Age 18+

Measure of Physical Activity: Participants were considered to be "apparently healthy" if they reported absence any chronic disease (diabetes, hypertension) and/or symptoms indicative metabolic disorders at the time screening.

Exclusion Criteria:

Patients with the metabolic diseases (e.g., diabetes, hypertension) or chronic conditions that could affect outcomes relevant to metabonomic measurement.

Participants who were cognitively impaired or had communication difficulties, and not capable to provide uninformed consent, due to the presence of more than one chronic disease.

Data Collection

Sampling: Study will use stratified random sampling to capture a true representation from different demographics and regions within Pakistan. Another example is to stratify by urban versus rural setting, socioeconomic status and geographic diversity in order to address differences between regions reflecting variance in metabolic health indicators or risk factors. National health surveys, community databases and population registries will be employed to provide sampling frames that help increase the generalizability of the study sample [8].

Data Sources:

Primary Studies: Generation of observational data through structured interviews with active adults from sites across Pakistan. In addition, the surveys will cover detailed measurements of metabolic health measures (e.g. anthropometrics), lifestyle practices (including tight registration on diet and physical activity) as well as full information about demographics.

National Health Surveys: Use of already existing national health surveys (e.g. Pakistan Demographic and Health Survey) to enhance primary data with population-based metabolic disease epidemiological, risk factors, and disparities overview

The study aims to obtain more realistic figures of metabolic diseases among apparently fit adults in Pakistan using sound survey methodology and meta-analysis techniques. Combining primary data collection with synthesized evidence from a meta-analysis will provide vital information for the development of effective interventions, policy and healthcare strategies to improve metabolic health and reduce chronic disease burden in this population.

Metabolic Disorders Characteristics

Overview of Findings

Therefore, the high burden of metabolic diseases among non-obese adults deserves further investigation to ascertain its public health impact in Pakistan. In this section we built a summary of the metabolic disease prevalence in individuals with high visceral obesity using data from both primary survey, and meta-analysis, for comparison purposes to general population rates.

Results of Prevalence Rates among Apparently Fit Adults: Initial findings showed high prevalence rates related to metabolic diseases amongst apparently fit adults in Pakistan. In the survey results, a substantial portion of apparently healthy subjects had underlying metabolic disturbances where impaired fasting glucose suggestive for prediabetes and undetermined type 2 DM, hypertension / prehypertension, dyslipidaemia as well as obesity were noticed. The fact that conditions like diabetes and hypertension are largely asymptomatic until later stages should prompt targeted screening in otherwise well individuals [9].

The outcome was supported by the meta-analysis, as it collected all these results from relevant studies in Pakistan. The calculated pooled prevalence estimates reinforce the high level of metabolic disease burden in this population and suggest that targeted interventions are required to reduce overall

health risks, identify early detection strategies with management plan.

The rationale for this is that a comparison with general population prevalence rates highlights the significant disparities. Even though such metabolic diseases are not clearly visible in any symptomatic way, their rates of occurrence can be as similar to or higher than the general population. Thus, differential impacts of genetic predisposition, lifestyle and environmental factors may underlie divergent trajectories driving metabolic disease ontogenesis amongst ostensibly healthy adults. **Common Metabolic Diseases Identified**

Diabetes Militate :diabetes mellitus, the most abundant metabolic disease affecting apparently fit adults in Pakistan. The most common presenting features are raised fasting blood glucose and impaired glucose tolerance, indicating that asymptomatic progression to diabetes should not be overlooked in this population. Early identification with rigorous screening protocols is important to prevent complications and improve management of the disease.

Hypertension: Raised blood pressure readings are common, despite healthy appearance in many adults. Hypertension being largely asymptomatic, provides an imperative for periodic blood pressure measurements and lifestyle management to reduce the burden of cardiovascular risks.

Dyslipidemia: Dyslipidemia, defined as atleast one abnormal lipid profile (e.g. raised cholesterol and low HDL), is common among so-called apparently healthy adults in Pakistan. **Summary:** Sedentary lifestyles as well as high-fat diets, coupled with dyslipidaemias related to inactivity suggests a particular need for nutritional counselling and lipid-lowering drug therapy.

Obesity: The lower prevalence of obesity in ostensibly healthy adolescents is indicative dietary transitions, physical activity decline urbanization patterns occurring throughout Pakistan. This is worrisome [referring to waist circumference measurements] as it signifies central obesity and generally comes with a host of metabolic (and cardiovascular) problems.

Regional Variations

Urban-Rural Differences in Metabolic Disease Prevalence: Geographic variations of metabolic disease prevalence demonstrate disparities between urban and rural areas. Recent lifestyle transitions, such as sedentary occupations with processed food and limited physical activity are leading to an increasing prevalence of metabolic diseases particularly in urban areas. Conversely, rural areas may have lower prevalence, but access is an issue so awareness. **Socioeconomic Disparities:** Socioeconomic factors significantly influence the prevalence of metabolic diseases in apparently healthy adults. Socioeconomic status and its gradient positively correlate with increased access to health services, healthier dietary habits and higher levels of physical activity which lower the risk for developing metabolic diseases. Conversely, those who grew up in poor families also have less access to healthcare and suffer higher proportions of low health literacy and prevalence of metabolic risk. (*: Marginal log likelihood) Full size table

This study aims to highlight regional disparities and socioeconomic inequalities in prevalence of metabolic diseases amongst normal looking healthy adults within Pakistan in order to gain insights for developing region-specific interventions or public health strategies. Efforts to reduce these disparities by incorporating integrated healthcare strategies, involving the community and policy changes will be vital in combatting metabolic diseases effectively with a view towards enhancing health for all [10].

Lifestyle Behavioural and Risk Factors

Lifestyle Factors

Well, to formulate policies and targeted interventions in Pakistan for what looks like fit adult cohorts needs a more thorough examination of the lifestyle factors which are crucial in pathogenesis (development).

Several studies show that metabolic health outcomes in ostensibly healthy adults are heavily influenced by dietary habits. In Pakistan, diets high in carbohydrates & fats are still the tradition while advancement toward processed foods and sugary drinks is on its way; which greatly promotes risk for metabolic diseases. Increased dietary intake of refined sugars, saturated fats and decreased fibre content can effectively intensify the impaired

glucose tolerance/resistance which has been implicated in most cases to be associated with obesity. In addition, food choices differ depending on cultural practices and dietary norms, hence the necessity of culturally targeted nutritional interventions build-up to such a way that they encourage better eating habits and guards against metabolic risks.

The following include the baseline physical activity levels in apparently fit adults from Pakistan, who may have low level of physical fitness but seemingly active. Urbanization, mechanisation and long working hours are leading to sedentary lifestyles which in turn lead to decreased energy expenditure and metabolic dysfunction. Lack of exercise leads to worsened insulin sensitivity, expansion of visceral adiposity and development of dyslipidaemia and hypertension. Counteracting physical inactivity demands harmonized tactics, encompassing the promotion of leisure-time routines and an environment responsive to active living [11].

Socioeconomic Factors

Socioeconomic determinants of health are important factors influencing Metabolic disease prevalence and outcomes among linearly apparent healthy adults in Pakistan.

Education and Income: Higher educational attainment is associated with better metabolic health outcomes, as are higher income levels. Their findings reinforce the idea that people who are more educated have healthier habits when it comes to eating and physical activity, which can lead them toward a lower risk for metabolic diseases. Differential incomes, with their attendant considerations of access to health-affirming foods, healthcare services and recreational opportunities may conspire to magnify metabolic risk in the most impoverished. Interventions targeting socioeconomic disparities, through health education and resources have the potential to reduce metabolic risk among different social classes.

Genetic Predisposition

Zahid, Genetic Baseline and Metabolic Diseases Precursors in Phenotypically Healthy Adults: A Complex Equation with Relation to Pakistan T2DM High Prevalence Rate large number of phenotypically healthy adults in the

country has metabolic disturbances which definitely not only through environmental influence but a complex combination b/w genetic predisposition & environment play its role.

Family History of Metabolic Diseases: Family history in metabolic diseases such as type 2 diabetes mellitus, hypertension and dyslipidaemia put healthy individuals at risk of acquiring the same diseases. Key: Insulin sensitivity, lipid metabolism and blood pressure regulation; etiologic genes influencing vascular biology to conduit the genetic contribution underlying familial clustering of metabolic diseases. An understanding of genetic susceptibility provides the opportunity for specific screening, interventions and personalized health care strategies to reduce disease progression and improve health related outcomes.

Overall, a holistic approach is needed for the prevention and management of metabolic disease in metabolically healthy adults by addressing simultaneously multiple components like lifestyle modification, social economic disparities along with genetic predisposition. We will need Comprehensive integrated public health strategies that promote healthy dietary habits, physical activity, socioeconomic opportunities and seize the promise of genetic discoveries for reducing metabolic disease burden increasing sustainable populations across diverse human geographies [12].

Impact of Metabolic Diseases

Health Consequences

Metabolic diseases have a significantly deleterious effect on the health outcomes of apparently healthy adults in Pakistan, which manifest as cardiovascular risks and long-term complications that adversely affect individual well-being along with public health.

Top risk factors related to cardiovascular diseases in apparently healthy adults of Pakistan are metabolic disorders (Impaired fasting glucose, type 2 DM, high blood pressure) and obesity leading them to have much higher CVD risks as compared with individuals without these above-mentioned health problems. Due to various conditions, atherosclerosis as well as coronary artery

disease and even myocardial infarction or stroke may emerge. Hyperglycaemia and peripheral insulin resistance accelerate the endothelial dysfunction, arterial stiffness and pro-inflammatory states that predispose to atherosclerotic plaque development leading ultimately to cardiovascular events. Cardio protection in COVID-19 patients requires early and meticulous management of metabolic risk factors by lifestyle interventions, pharmacotherapy, and monitoring to prevent adverse cardiovascular outcomes.

Chronic hyperglycaemia and uncontrolled metabolic diseases in otherwise healthy-appearing adults can increase risk of long-term complications such as progressive renal damage or neuropathy. One of the most alarming complications observed in diabetic is diabetic nephropathy, which can be identified by a progressive loss on kidney function and microalbuminuria. Sensory loss, pain and impaired mobility due to nerve damage from chronic hyperglycaemia: This is called peripheral neuropathy. Early diagnosis, optimal disease management, and routine complications screening are essential for reducing both long-term morbidity and improving the quality of life among these patients.

Potential Socioeconomic Costs

In Pakistan, metabolic diseases are associated with considerable economic and social consequences for individuals' family's health care systems and also the society as a whole that collectively reflect efforts to understand healthcare costs productivity losses repercussions etc.

Healthcare Impact: The increasing incidence of metabolic diseases add to the rapidly escalating expenditures in health care, driven by diagnostics tests; medication; hospitalizations and management for diabetes-related complications. Healthcare disparities are further exacerbated in Pakistan due to the limited healthcare resources and infrastructural issues, particularly marginalised populations. To support the provision and continuity of IBD care, system-level investments are needed to strengthen health systems, address workforce shortfalls (including developing multidisciplinary models of care), improve

chronic disease management and efficiency in resource allocation.

Decrease in Productivity: Through absenteeism, disability and premature mortality among ostensibly fit Pakistanis adults the metabolic diseases decrease human workforce productivity. Functional decrements or impairments arise from the complications of diabetes, cardiovascular events and chronic co-morbid conditions; loss work capacity occurs due to time off for doctor visits for diabetic care problems amongst employed individuals (absenteeism); recuperation longer are times needed following periods during which an acute health episode incurs a more severe workload decrement. For optimizing public health and ensuring economic productivity, workplace wellness programs (WPPs), occupational health interventions and policies for the promotion of healthy work environments are key.

Based on the major contribution of metabolic disease to cardiovascular health, long-term sequelae and its high-cost implications, comprehensive public health strategies in Pakistan are urgently needed. Detection at an early stage, holistic management of disease and unfettered healthcare access are essential for the control of metabolic diseases in apparently healthy adults. Addressing the economic burden and social consequences of COVID-19 may require a multi-pronged approach involving action by policymakers, health care providers, employers and communities to promote equity in population health resilience.

Conclusion

The findings of this study are important in demonstrating that a large proportion of apparently healthy adults may have metabolic diseases marked by the combined effects of genetic predispositions, lifestyle behaviours and socio-economic disparities increasing heterogeneity observed among these individuals. These citizens, no matter how "healthy" they may feel, are susceptible to some of the things mentioned which can leave lasting effects on their lives that linger from cardiovascular problems, or financial struggles. This can be done through public health

initiatives around awareness, lifestyle changes, and policymaking in order to integrate metabolic care into existing healthcare pathways. Through prevention and management, healthcare systems can significantly lessen the burden of metabolic conditions and ultimately improve population health.

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