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Chronic Obstructive Pulmonary Disease (COPD) in Younger Adults: Challenges and Considerations – A Review

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Abstract

Chronic Obstructive Pulmonary Disease (COPD) phenomenon rapidly converting into chronic, significant health issues for many young adults. A disease calculated for older age gives way to early-onset COPD, which creates new issues for diagnosing and treating the illness and even interacts with the quality of life. The article reviews epidemiology, risk factors, pathophysiology, clinical presentation, and treatment considerations related to this set of conditions. From those risk factors, early-onset COPD would have some other unique ones in terms of genetic predisposition, environmental pollutants, work hazards, and new smoking trends, such as vaping. The pathophysiology may be attributed to the complex interplay between airway inflammation, small airway disease, impaired lung development, and oxidative stress. Diagnosing COPD in younger adults is riddled with problems, such as atypical symptoms and the lack of awareness among health care providers for wrong diagnosis with asthma or other respiratory conditions. Management techniques are threatened with delayed diagnosis, absence of age-specific treatment guidelines, nonadherence to set treatment regimes, and other psychosocial factors. It directly threatens the quality of life among younger adults, with adverse effects in terms of affecting physical performance, psychological domain, work opportunities, and natural increase in health costs. Future research efforts should strengthen early detection tools, further develop personalized treatment pathways, and seek to introduce novel therapies and psychosocial dimensions to disease-oriented research agendas. Longitudinal cohort studies and digital health solutions can be brought together to help develop an understanding and response in the management of COPD among younger populations. In young adults, it is vital to create greater consciousness, promote early intervention, and tailor preventive measures to alleviate the increasing burden of illness due to COPD.

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INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) refers to a progressive respiratory disorder caused by airflow limitation that is persistent over time and chronic inflammation of the airways. Until now, COPD has traditionally been associated with older years. However, there is increasing evidence of a rise in cases of COPD among younger adults, which poses major clinical and public health challenges [1]. Early-onset COPD is frequently undiagnosed, and it has distinct risk factors: inherited predisposition,

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environmental pollution, occupational hazards, and shifting smoking habits like electronic cigarette use [2]. This burden of disease in younger adults is often underestimated, resulting in late intervention and increased morbidity.

The pathophysiology of COPD in younger adults is complex and different from that in later-onset cases. Tobacco smoking is still largely responsible; however, modern influences, such as exposure to both indoor and outdoor air pollution, recurrent respiratory infections, and α1-antitrypsin (AAT) deficiency, are all important in the progression of the disease [3]. Moreover, COPD is believed to affect older individuals mostly, which leads to a misdiagnosis by attributing the symptoms to asthma or other respiratory diseases [4]. Thus, timely medical attention is afforded to very few younger patients, thereby increasing the pace of lung function decline and risk of chronic disability [5].

COPD in younger adults presents a challenge for well-being because it also means loss to employers and increased burden on mental health and health care costs. Good early diagnostics and personalized attention are imperative to prevent the progression of the disease and improve the lives of affected individuals [6]. Lifestyle change, pharmacotherapy, and pulmonary rehabilitation are vital in managing diseases. However, awareness, policy reform, and targeted research are immediately required to address the specific needs of this patient group [7].

This review aims to present a comprehensive account of COPD in younger adults in terms of epidemiology, risk factors, pathophysiology, diagnostic challenges, and treatment considerations and looks into future perspectives in research and Public Health strategies to downscale the growing burden of the disease [8].

EPIDEMIOLOGY OF COPD IN YOUNGER ADULTS

It is generally associated with older adults; however, recent observations from epidemiological studies indicate an increasing incidence among younger populations. COPD usually develops after exposure to risk factors, such as tobacco smoke and environmental pollution, over an extended period. Nevertheless, studies have shown that early-onset COPD may start developing in adolescence or early adulthood and present with symptoms prior to the age of 50 [1]. Population-based studies estimate that from 10% to 15% of all COPD cases occur in patients younger than 50 years, whereby some show evidence that this group may have the disease not diagnosed or misdiagnosed [4].

Differences in environmental exposure, access to health care facilities, and genetic susceptibility around the world account for varied rates of prevalence of COPD among the younger age group. In developed countries, early-onset COPD is often confined to smoking and occupational hazards, while in low- and middle-income nations, significant contributions come from biomass fuel use, early-life respiratory infections, and household air pollution [9]. Recently, it has been revealed through a large multicounty study that about 6–8% of the young adults aged 20–44 years display obstructed airflow generally met with conditions suggestive of COPD, and the burden for such conditions was found to be more in settings with low air quality and high rates of childhood respiratory diseases [10].

Underdiagnosis of COPD in younger adults remains a terrible problem. Most of these people with early presentations are misdiagnosed with asthma or other respiratory disorders [8]. Epidemiological surveys further show a lack of spirometry testing in younger populations, leading to delayed diagnosis and treatment [5]. Moreover, recent findings have shown that early functional lung impairment from childhood infections and prematurity or poor lung growth means a person is significantly more likely to develop COPD in adulthood [7]. Identifying these patterns is thus very important for early intervention strategies meant to reduce the cost of the disease in younger individuals.

Increased focus on current and prospective high-risk populations will contribute to decreasing the future burden of COPD. Early detection depends on identifying high-risk groups with improved strategies. Demographic shifts in the prevalence of early-onset conditions among younger populations

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raise the need for epidemiological studies, Public Health initiatives, and awareness campaigns targeted toward understanding certain risk factors for early-onset COPD [6].

ETIOLOGY AND RISK FACTORS

Young adults develop COPD through a multifactorial interplay of genetic, environmental, and lifestyle factors. Late-onset COPD is strongly associated with smoking; on the other hand, early-onset COPD largely results from the interplay between genetic factors and environmental exposures during the early years of life [1]. Correctly identifying risk factors for this early form of COPD is vital in early diagnosis and preventive measures aimed at reducing the burden of the disease on young populations [4].

Genetic Susceptibility

Genetic susceptibility plays quite an important role in the very development of COPD in the younger age group. The prime example of a well-characterized genetic factor is AAT deficiency, a genetic disorder that causes early-onset emphysema due to a lack of protection of lung tissue from proteolytic enzymes [11]. Those with severe AAT deficiency are thought to have an increased risk of subsequently developing COPD even in the absence of smoking [12]. Furthermore, since the advent of genome-wide association studies (GWAS), genetic polymorphisms in several loci have been associated with the lung function decline and increased susceptibility to COPD in nonsmokers [13].

Environmental and Occupational Exposures

Environmental pollution and occupational exposure contribute heavily to the development of COPD in young adults. Much research has reported that prolonged exposure to biomass-fuel smoke, inland pollution, and traffic-related air pollution impair lung function and result in early-onset COPD [14]. In developing countries, cooking and heating on solid fuels remain as a major attributable risk for nonsmoking-related instances of COPD [15]. Similarly, exposure to dust, chemical agents, and fumes peculiar to some industries, such as mining, construction, and agriculture, have developed into a recognized contributor to increased prevalence of COPD in younger workers [16].

Smoking, Vaping, and Other Substance Use

Smoking is the world's primary etiological factor for COPD. Yet increasingly, the younger adult population is engaging in vaping and e-cigarette use, substances that have shown to induce chronic airway inflammation and damage to the lung [17]. Studies have shown that chronic airway remodeling and lung function impairment may arise due to long-term vaping, akin to that produced in traditional smokers [18]. An association has also been shown for secondhand smoke exposure in childhood as an added risk factor for the future development of COPD [19]. The inhalation of otherwise legal substances, like marijuana and illicit drugs, may further perpetuate early respiratory dysfunction [20].

Factors Related to Early Life and Lung Development

Infections of the respiratory tract in early life, premature birth, and poor lung development are some of the offending factors enhancing susceptibility to COPD in younger adults [21]. Evidence indicates that persons with a childhood history of asthma, recurrent lower respiratory tract infections, or neonatal lung diseases may be at higher risk of developing COPD [22]. Poor lung growth during childhood, mostly due to malnutrition or exposure to maternal smoking, resulted in lower peak lung function and thus increased susceptibility to early airflow limitation [23].

The pathogenesis of COPD in younger adults is multifactorial and includes genetic predisposition, environmental and occupational exposures, history of smoking, and early-life issues with lung development. Identification of high-risk people and preventive measures, such as mitigation of air pollution exposure, smoking cessation programs, and early spirometry screening, are paramount in minimizing the burden of early-onset COPD [6].

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PATHOPHYSIOLOGY OF COPD IN YOUNGER ADULTS

COPD is defined as a persistent limitation of air flow caused by a combination of diseases affecting the small airways and destruction of the parenchyma, resulting in progressive respiratory dysfunction [1]. It is sectional among younger adults due to the different set of pathophysiological functions as compared to older individuals, which have more influences coming from early-life lung development issues, genetics, and atypical inflammatory [5]. These should be assessed to arrive at an early diagnosis and targeted interventions.

Even if from Airway Inflammation

The inflammation in COPD is itself attributed, caused by the imbalance between the pro-inflammatory and anti-inflammatory weavers of mediators, which lead to chronic damage of the small airways [24]. It suggests that for younger adults, airway inflammation was quite neutrophilic-predominant, but there were also a few cases with eosinophil involvement, probably more like asthma [25]. These then activate an influx of neutrophils, macrophages, and CD8 T cells during prolonged exposure to smoking, vaping, or environmental pollutants that dan critical quantities of proteolytic enzymes directed at matrix metalloproteinases and neutrophil elastase degrading the lung parenchyma [3]. Activation of fibroblasts and deposition of the extracellular matrix will also cause remodeling of the airways and thickening of the air walls, which contributes to increasing the resistance of airflow [26, 27].

Small Airways Diseases and Early Emphysema

Among young adults, a common feature of COPD at an early stage is an unequal disease that involves very small airways called small airway disease (SAD). SAD is characterized by narrowing of the lumen, increased mucus production, and peribronchiolar fibrosis, which increases airway resistance and eventually causes airflow obstruction [28]. In genetically predisposed individuals, AAT deficiency will potentially lead to early-onset emphysema, causing a more rapid destruction of the alveolar walls [11]. In younger adults, the emphysematous changes are likely to be more pan lobular, especially in the lower lobes, whereas older adults are more likely to show centrilobular emphysema because of smoking exposure for many years [29].

Impaired Development of Lungs and Aging of Lungs

This is another mechanism that is very critical in the pathogenesis of COPD in younger adults, the impaired development of the lungs during childhood and adolescence, which exposed them to airflow limitation earlier in life [21]. Several epidemiological studies have indicated that very important mechanisms conducive to suboptimal lung growth include factors, such as preterm births, low birth weight, childhood respiratory infections, and maternal smoking, are leading to lower FEV_1 (forced expiratory volume in one second) in early adulthood [30]. In future, these individuals would be subjected to a faster decline of lung function, increasing the risk of developing COPD at a younger age [31]. Moreover, yet another mechanism of early age onset appears to implicate accelerated lung aging, which is defined by telomere shortening and mitochondrial dysfunction [32].

Stress Oxidative and Dysfunction

Oxidative stress is central to the pathophysiology of COPD, as it causes damage to the airway epithelium, mitochondrial dysfunction, and subsequent apoptosis [33]. Among younger adults, oxidative stress is aggravated by environmental exposures, such as cigarette smoke or passive smoking, vaping, and air pollution, which lead to excessive production of reactive oxygen species (ROS) [34]. ROS cause damage to lung epithelial cells and weaken antioxidant defenses while activating inflammatory pathways, resulting in remodeling of the airways and further added damage through emphysema [35]. Mitochondrial dysfunction in COPD patients has also been attributed to increased apoptosis of alveolar cells, disrupting the homeostasis of the lung and accelerating the pathogenesis of the disease [36].

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Although adding airway inflammation dissimilar to that seen in older adults, young adults generally present with the additional complicating factor of bearing a congenital predisposition to lung growth deformities, with an early tendency for airway remodeling; thus, the imperative of early diagnosis and intervention is underscored. Future research in this area will also provide new avenues for the development of specific treatments for early-onset COPD targeting the very pathophysiological mechanisms involved [6].

CLINICAL PRESENTATION AND DIAGNOSIS

Clinical Presentation of COPD in Younger Adults

COPD presents itself in younger adults with rather atypical or subtle symptoms, thereby leading to underdiagnosis and delayed treatment [1]. Unlike older patients, dyspnea may not be significant for young patients early on; respiratory complaints can instead have presentations resembling asthma, chronic bronchitis, or even anxiety-related symptoms [5]. Other symptoms associated with this illness include persistent cough, sputum production, episodic wheezing, and exertional breathlessness, which worsen over time [37]. Younger adults might instead show symptoms of COPD intermittently; most not always continuously progress, particularly for those having environmental exposures (e.g., occupational hazards, smoking, or vaping) or genetic predisposition, such as AAT deficiency (AATD) [38]. In addition, some may complain about recurrent respiratory infections, having unexplained fatigue and chest tightness, further complicating differential diagnosis from other pulmonary disorders [39]. Therefore, early recognition of such symptomatology is essential for intervention and subsequent disease management [40].

Diagnostic Approach to COPD in Younger Adults

Clinical History and Risk Assessment

Diagnosis involves a detailed clinical history of the younger adult, including current and past smoking habits, environmental exposure to pollutants, family history of respiratory diseases, and an apparent past account of childhood lung infections and comorbid illnesses [41]. Preterm birth, low birth weight, or childhood asthma history all increase susceptibility to earlier onset of COPD at younger ages [42]. A history of work exposure to dust, fumes, or chemicals (e.g., silica, coal dust, and organic solvents) would also add to the factors considered under this subsection [43].

Spirometry and Pulmonary Function Tests

Spirometry constitutes today's gold standard for COPD diagnosis, even in the younger age group. It quantifies forced expiratory volume in one second (FEV_1), and the forced vital capacity (FVC) ratio ($FEV_1/FVC < 0.70$ post-bronchodilator confirms airflow obstruction) [44]. Therefore, borderline spirometric abnormalities for COPD in the early stages may manifest in younger individuals, therefore, requiring more sensitive measures, such as impulse oculometry or nitrogen washout tests for lung function evaluation [45].

Imaging Studies (Chest X-ray and High-Resolution CT Scan)

Generally, it is done to exclude other lung diseases, but it is not much of a sensitive test for detecting early damage to the lung due to COPD [46]. A high-resolution computed tomography (HRCT) scan is used where early-probable emphysema or SAD is suspected. HRCT detects early changes of emphysema, airway thickening, and gas trapping; especially for those with AATD or occupational COPD [47].

Biomarkers and Genetic Testing

Biomarkers, for example, exhaled nitric oxide (FeNO), blood eosinophil count, C-reactive protein (CRP), etc., are helpful in distinguishing COPD from diseases like asthma or other inflammatory lung conditions in younger subjects [48]. In any patient less than 45 years old presenting with unexplained airflow limitation or a strong family history of COPD, genetic testing for AATD is customarily undertaken [49]. The identification of AATD allows for early intervention with specific management strategies and even augmentation therapy [50].

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Exercise Testing and Cardiopulmonary Assessments

Exercise intolerance and gas exchange impairment assessment in the younger adults suspected of COPD includes procedures like 6-minute walk tests (6MWT), evaluation of cardiopulmonary exercise testing (CPET), and diffusing capacity of the lungs for carbon monoxide (DLCO) tests [51]. These tests help especially if their spirometry has shown borderline results, but their respiratory symptoms remain unrelieved [52].

Challenges Associated with Diagnosing COPD in Younger Adults

Being Misdiagnosed with Asthma or Other Respiratory Conditions

COPD in younger adults is frequently misdiagnosed as asthma, chronic bronchitis, or even dyspnea from anxiety, often due to the overlap of symptoms [53]. The obstruction in COPD is usually irreversible, unlike in asthma, which exhibits significant bronchodilator reversibility [54].

Lack of Awareness Among Health Care Providers

Many clinicians fail to consider a diagnosis of COPD for their younger patients. Accordingly, they underutilize spirometry and imaging workups [55]. Mild or intermittent early symptoms in the early phase, symptoms in the young adult presenting with COPD may be very mild and easily overlooked [56].

Early and prompt diagnosis of COPD in younger adults is essential to delay the progression of the disease and improve long-term outcome. A holistic approach to the diagnostic workup, including clinical history, spirometry, imaging, and biomarker evaluation, is warranted to distinguish COPD from other respiratory disorders. Awareness among healthcare professionals will help reduce misdiagnosis and ensure an intervention in time [57].

CHALLENGES IN MANAGEMENT AND TREATMENT

Delay in Diagnosis and Poor Awareness Mechanism

COPD is not diagnosed or is misdiagnosed in younger adults because it has been traditionally considered a disease of older people. Many younger patients with chronic cough, dyspnea, or sputum production are misdiagnosed with asthma or other respiratory conditions because of low clinical suspicion of COPD [5]. Also, underuse of spirometry in primary care settings contributes to delayed diagnosis and disease progression [37].

Absence of Treatment Guidelines Based on Age

Current treatment guidelines for COPD are based mainly on studies involving older people, so it is uncertain if younger patients benefit equally from standard therapies, such as long-acting bronchodilators and inhaled corticosteroids [41]. The absence of any personalized management strategy for early-stage COPD in younger adults remains a roadblock [39].

Smoking Cessation and Environmental Exposures

Smoke cessation is a central strategy in managing COPD, but younger adults generally show higher dependence on nicotine and lower quit rates than older patients [44]. The latest trends in electronic cigarette use and vaping interfere with smoking cessation attempts even more since their consequences on lung health in the long run are still uncertain [43]. Besides, these environmental and occupational exposures, for example, air pollution and chemical inhalations, contribute to COPD risk and are hard to modify in the younger working population [57].

Poor Treatment Adherence

Due to limited disease perception, financial constraints, and hectic lives, young patients with COPD poorly adhere to inhaler therapy and lifestyle modifications [55]. Many younger patients suffer from incorrect inhaler technique or cease medication prematurely, leading to frequent exacerbations and lung function decline [52].

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Psychosocial and Mental Health Problems

Being diagnosed with a chronic, progressive illness at a young age can lead to anxiety, depression, and social isolation. The absence of support groups or mental health interventions intended for younger patients with COPD aggravates these concerns [56].

Barriers to Pulmonary Rehabilitation

Younger patients with COPD are not accessing pulmonary rehabilitation (PR) programs due to problems with work, familial pressures, and the stigma stemming from a program that caters primarily to the older adults' population [58]. Accessibility issues and low awareness about PR compound the problems of limited participation [54].

IMPACT ON QUALITY OF LIFE AND SOCIOECONOMIC BURDEN

Impediments of Physical and Functional Nature

Young adults with COPD experience a great deal of physical limitations that hamper the individual's performance of daily activities and participation in an active lifestyle. Symptoms, such as dyspnea, fatigue, and frequent exacerbations, cause reduced exercise tolerance, leading to a sedentary lifestyle and muscle deconditioning [59]. This decrement in physical outcome can contribute to reduced work productivity and an increased dependency on healthcare services [60].

Psychological and Emotional Impact

COPD happens not only as a physical ailment, but psychologically burdens a patient, most especially in younger adults, where there is the progression of disease that is chronic. This further leads toward anxiety, depression, and social isolation [61]. Research work shows that younger patients suffering from COPD usually fall into the higher psychological distress category when compared to older patients. This disorder is mainly attributed to concerns over career security, financial stability, and family obligations [62]. The absence of mental health support in the management of COPD has aggravated this difficulty [63].

Employment and Economic Implication

There are various employment problems for young patients with COPD. Such problems include absenteeism, reduced efficiency while at work, and even loss of jobs due to a multitude of exacerbations and hospital admissions [64]. This leads to early retirements or changes in employment for many individuals, making them financially insecure [65]. That is even worsened by expensive treatment floored by medication, hospitalization, and pulmonary rehabilitation programs [66].

Social and Family Life Disruption

Severe symptoms, such as fatigue and breathlessness, limit younger individuals with COPD from participating fully in social events and family functions, resulting, in turn, in isolation and frustration [67]. Family members, therefore, mostly end up being primary caregivers, which creates emotional and financial stress in most households [68].

Pressure on the Healthcare System

Due to the increasing prevalence of COPD among all age groups, especially the younger age group, increased pressure on the healthcare system continues to develop. Such needs include frequent consultations with hospitals, admissions, and maintenance of long-term treatment strategies that will turn around to very high direct healthcare costs and resource allocation challenges [69]. However, there are no sound interventions directed toward younger patients, which exacerbate the already difficult disease management and prevention process [70].

FUTURE DIRECTION AND RESEARCH GAPS

Need for Early Detection and Screening Strategies

Current COPD screening programs primarily target older adults and long-term smokers, often overlooking younger populations with early-stage disease or genetic predisposition [71]. Future

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research should focus on developing early detection tools, including biomarkers, artificial intelligence-based imaging techniques, and predictive models to identify COPD in younger individuals before significant lung function decline occurs [72].

Development of Age-Specific Treatment Guidelines

Most COPD management guidelines are based on clinical trials involving older patients, leaving a significant gap in age-specific treatment strategies for younger adults [41]. Future studies should assess whether younger patients respond differently to bronchodilators, corticosteroids, or emerging biologic therapies. Additionally, research on personalized medicine and genotype-driven therapies is needed to optimize treatment approaches for early-onset COPD [26].

Understanding the Role of Environmental and Occupational Exposures

While tobacco smoking remains a primary risk factor, occupational and environmental exposures play a significant role in early-onset COPD [43]. More longitudinal studies are required to assess the impact of air pollution, vaping, biomass fuel exposure, and occupational hazards on younger adults. Establishing workplace policies to reduce exposure to harmful inhalants could be a key preventive measure [73].

Exploring Novel Therapies and Disease-Modifying Agents

Despite advances in COPD treatment, there is no cure or disease-modifying therapy that can halt disease progression, especially in younger adults. Research should focus on regenerative medicine approaches, stem cell therapy, and anti-inflammatory biologics to target early disease mechanisms [74]. Investigating the role of gut-lung axis interactions and microbiome-based therapies could also offer new treatment avenues [75].

Addressing Psychosocial and Mental Health Aspects

The psychosocial impact of COPD in younger adults remains an understudied area. There is a need for research on mental health interventions, digital health support systems, and peer-support programs tailored for younger COPD patients [76]. Additionally, behavioral studies can help understand barriers to treatment adherence and improve patient engagement in self-care practices [77].

Integration of Digital Health and Telemedicine

The rise of telehealth and wearable monitoring devices makes the integration of digital health solutions into COPD care a way to enhance remote monitoring, early detection of exacerbations, and treatment adherence [78]. Research needs to encompass the assessment of the efficacy of smart inhalers, AI-driven predictive analytics, and mobile health applications in the context of young populations with COPD [79].

The Setting-up of Longitudinal Cohort Studies

Validation with longitudinal evidence for the gradual worsening of COPD in young adults is missing. Large-scale, multi-centered cohort studies are to be set up to apprehend the natural history of early-onset COPD, the effect of lifestyle factors, and potential targets for therapeutic intervention [57].

CONCLUSIONS

COPD or Chronic Obstructive Pulmonary Disease has emerged as one of the major health concerns currently for the younger adult populations. It presents certain peculiarities regarding diagnosis and management to be followed, and the impact it has on the quality of life regarding these patients. These are said to have unique risk factors that include genetic predisposition, environmental pollutants, occupational hazards, and the evolving pattern of smoking-vaping. Pathophysiology involves complex associations between airway inflammation, SAD, impaired lung development, and oxidative stress. It is often difficult to diagnose COPD in younger adults due to the atypical symptoms and unsatisfactory recognition of the condition among healthcare providers, and misdiagnosis as asthma or other

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respiratory conditions. The management of those young adults diagnosed with COPD is hampered by late diagnosis, no age-specific treatment guidelines, poor adherence, and psychosocial challenges. It has curtailed the quality of life for many young adults by imposing several physical limitations, psychological distress, employment difficulties, and an escalation in the healthcare burden. Research in the future is likely to engage in early detection, personalized treatment, innovation, and psychosocial perspectives of the disease in question.

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