

# Asthma Management: Biologics, Precision, Digital Health

Ravi Mehra\*

*Department of Pulmonary & Critical Care, Riverview University Hospital, Corbridge, Canada*

## Introduction

Dupilumab, a biologic therapy, shows strong real-world effectiveness in managing severe asthma across various patient populations, including those with comorbidities like atopic dermatitis or chronic rhinosinusitis. The treatment significantly reduces exacerbation rates and improves lung function, aligning with findings from clinical trials and supporting its role in tailored asthma management [1].

Precision medicine is transforming asthma treatment, moving beyond broad classifications to patient-specific biologic therapies targeting underlying inflammatory pathways. Emerging biologics like mepolizumab, reslizumab, benralizumab, and dupilumab are revolutionizing care for severe asthma by addressing specific endotypes and improving clinical outcomes, emphasizing the need for biomarker-guided treatment decisions [3]. Tezepelumab, a first-in-class biologic targeting thymic stromal lymphopoietin (TSLP), demonstrated significant reductions in asthma exacerbation rates and improved lung function across a broad range of patients with severe, uncontrolled asthma, irrespective of baseline eosinophil counts. The NAVIGATOR study highlights its potential as a broad-spectrum treatment for severe asthma [5]. These advancements underscore a pivotal shift towards individualized and highly effective therapeutic strategies.

Exposure to various air pollutants, including particulate matter (PM<sub>2.5</sub>, PM<sub>10</sub>), nitrogen dioxide (NO<sub>2</sub>), and ozone (O<sub>3</sub>), is consistently associated with an increased risk of asthma exacerbations in children. This systematic review underscores the critical public health implications of air quality on pediatric asthma management and highlights the need for targeted interventions to reduce exposure [2]. The COVID-19 pandemic significantly impacted asthma management, leading to changes in healthcare utilization, medication adherence, and exacerbation rates. While some studies showed reduced exacerbations due to masking and reduced exposure to other respiratory viruses, overall, the pandemic necessitated adaptive strategies in care delivery, including increased telemedicine use, for asthma patients [6]. This highlights the dynamic interplay between environmental and societal factors and asthma care.

E-health and telemedicine solutions significantly enhance asthma management by improving medication adherence, self-management skills, and overall disease control. These digital interventions offer flexible and accessible care, particularly beneficial during times when in-person visits are challenging, demonstrating their potential to integrate into routine asthma care for better patient outcomes [4]. Bronchial thermoplasty remains a viable non-pharmacological option for selected patients with severe, uncontrolled asthma who do not respond adequately to maximal medical therapy. While its precise mechanism is still being fully elucidated, long-term data suggest sustained improvements in quality of life and reduction in severe exacerbations, making it a crucial consideration in personalized treatment plans [7]. Complementary approaches also show promise; while no single diet

definitively cures asthma, certain dietary patterns and specific nutrients demonstrate potential benefits in modulating asthma symptoms and exacerbations. A diet rich in fruits, vegetables, and omega-3 fatty acids, and low in processed foods, may have a protective effect, suggesting dietary modifications could be a complementary strategy in asthma management [8].

Fundamental research is deepening our understanding of asthma's underlying biological mechanisms and genetic predispositions. Airway epithelial cells play a pivotal role in asthma pathophysiology, acting as the first line of defense and orchestrating immune responses. Dysfunction in these cells contributes to airway inflammation, hyperresponsiveness, and remodeling. Understanding these mechanisms opens new avenues for therapeutic interventions targeting epithelial barrier function and signaling pathways [9]. Genome-wide association studies (GWAS) have identified numerous genetic loci associated with asthma susceptibility, shedding light on the complex interplay of genetic factors. These discoveries enhance our understanding of asthma's etiology and progression, potentially paving the way for personalized risk assessment and the development of targeted preventive or therapeutic strategies [10]. Together, these diverse research areas are collectively shaping a more nuanced and effective approach to global asthma management.

## Description

The current landscape of asthma management is characterized by significant advancements across therapeutic, environmental, and foundational research fronts. Biologic therapies represent a major leap forward, offering highly targeted interventions for severe asthma. Dupilumab has demonstrated robust real-world effectiveness, leading to substantial reductions in exacerbation rates and improvements in lung function across diverse patient populations, even those with co-existing conditions like atopic dermatitis or chronic rhinosinusitis [1]. This efficacy aligns with clinical trial data and supports its integral role in personalized asthma care. Precision medicine further refines this approach, moving beyond generalized treatments to patient-specific biologic therapies that address underlying inflammatory pathways unique to an individual. Prominent biologics such as mepolizumab, reslizumab, benralizumab, and dupilumab are actively transforming the care for severe asthma by targeting specific endotypes and significantly enhancing clinical outcomes, thereby emphasizing the critical importance of biomarker-guided treatment decisions [3]. Adding to this armamentarium, Tezepelumab, a first-in-class biologic targeting thymic stromal lymphopoietin (TSLP), has shown remarkable efficacy, producing significant reductions in asthma exacerbation rates and improved lung function across a broad spectrum of patients with severe, uncontrolled asthma, irrespective of their baseline eosinophil counts. The NAVIGATOR study notably underscores its potential as a versatile, broad-spectrum treatment for severe asthma [5].

Environmental factors continue to exert a profound influence on asthma exacerbations, particularly concerning vulnerable populations like children. Exposure to a range of air pollutants, including various particulate matters (PM<sub>2.5</sub>, PM<sub>10</sub>), nitrogen dioxide (NO<sub>2</sub>), and ozone (O<sub>3</sub>), is consistently and strongly linked to an increased risk of asthma exacerbations in children [2]. This highlights urgent public health implications related to ambient air quality and the imperative for focused interventions to mitigate exposure risks. The global COVID-19 pandemic also created unique challenges and shifts in asthma management. It significantly impacted healthcare utilization patterns, medication adherence, and overall exacerbation rates [6]. While some studies observed a decrease in exacerbations, potentially attributable to widespread masking and reduced transmission of other common respiratory viruses, the pandemic globally necessitated highly adaptive strategies in care delivery. A notable shift included the increased adoption and utilization of telemedicine services for asthma patients, reflecting the need for flexible and accessible healthcare solutions [6].

Technological advancements and complementary non-pharmacological strategies are also playing an increasingly vital role in comprehensive asthma care. E-health and telemedicine solutions have been instrumental in significantly enhancing asthma management by fostering better medication adherence, empowering patients with improved self-management skills, and contributing to overall superior disease control [4]. These digital interventions provide inherently flexible and readily accessible care, proving particularly valuable during periods when traditional in-person visits posed significant challenges. Their demonstrated potential for seamless integration into routine asthma care promises consistently better patient outcomes [4]. For select patients with severe, uncontrolled asthma who have not responded adequately to maximal medical therapy, bronchial thermoplasty remains a viable and important non-pharmacological option [7]. Although its precise mechanism of action is still being fully elucidated, long-term data consistently point to sustained improvements in patients' quality of life and a significant reduction in severe exacerbations, making it a crucial consideration in highly personalized treatment plans [7]. Furthermore, while a definitive dietary cure for asthma does not exist, certain dietary patterns and specific nutrients have shown promising potential benefits in modulating asthma symptoms and exacerbations. A diet rich in fruits, vegetables, and omega-3 fatty acids, coupled with a reduced intake of processed foods, may offer a protective effect, suggesting dietary modifications as a valuable complementary strategy in holistic asthma management [8].

At the fundamental biological level, research continues to unravel the intricate mechanisms underpinning asthma. Airway epithelial cells, for instance, are now recognized as playing a pivotal and multi-faceted role in asthma pathophysiology [9]. They act as the body's primary line of defense and are central to orchestrating complex immune responses within the airways. Dysfunction in these crucial cells directly contributes to the characteristic airway inflammation, hyperresponsiveness, and remodeling observed in asthma. A deeper understanding of these intricate cellular mechanisms is opening exciting new avenues for innovative therapeutic interventions specifically targeting epithelial barrier function and critical signaling pathways [9]. Concurrently, large-scale Genome-wide association studies (GWAS) have been instrumental in identifying numerous genetic loci robustly associated with asthma susceptibility [10]. These groundbreaking discoveries are shedding invaluable light on the complex interplay of genetic factors that contribute to the disease. Such advancements profoundly enhance our fundamental understanding of asthma's etiology and its progressive development. Crucially, these insights are paving the way for more precise and personalized risk assessment strategies, as well as the potential development of highly targeted preventive or therapeutic interventions in the future [10].

Collectively, these ongoing developments across therapeutics, environmental health, digital care, and fundamental science converge to inform a progressively sophisticated and patient-centric approach to asthma management. This compre-

hensive perspective aims to optimize treatment outcomes, enhance quality of life, and address the multifaceted nature of this chronic respiratory condition.

## Conclusion

Current advancements in asthma management span biologic therapies, digital health, and foundational research. Dupilumab and Tezepelumab exemplify effective biologic treatments for severe asthma, reducing exacerbations and improving lung function across varied patient profiles, irrespective of eosinophil counts for Tezepelumab [1, 5]. Precision medicine now tailors these biologic interventions, like mepolizumab and benralizumab, to specific inflammatory pathways and endotypes, guided by biomarkers [3]. Environmental factors significantly influence asthma; air pollutants like PM<sub>2.5</sub> and NO<sub>2</sub> increase exacerbation risks, especially in children, highlighting public health concerns [2]. The COVID-19 pandemic shifted care towards adaptive strategies, including increased telemedicine use, even as some studies noted reduced exacerbations potentially due to masking [6]. E-health and telemedicine actively enhance medication adherence and self-management, offering flexible care solutions [4]. Non-pharmacological options, such as bronchial thermoplasty, provide sustained benefits for selected severe cases [7], while dietary patterns rich in fruits and omega-3s may offer complementary protective effects [8]. Research into airway epithelial cell dysfunction reveals its central role in inflammation and hyperresponsiveness, suggesting new therapeutic targets [9]. Genome-wide association studies are uncovering genetic predispositions, refining our understanding of asthma's etiology and paving the way for personalized risk assessment and interventions [10].

## Acknowledgement

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## Conflict of Interest

None.

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**\*Address for Correspondence:** Ravi, Mehra, Department of Pulmonary & Critical Care, Riverview University Hospital, Corbridge, Canada, E-mail: r.mehra@riveuh.ca

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