Food Allergies and Sensitivities: Current Research and Future Directions

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Abstract: Food allergies and sensitivities represent complex and dynamic areas of study, characterized by distinct immunological and non-immunological responses to specific dietary elements. This review explores the current landscape and future directions in research, diagnostics, and management of these conditions. A nuanced understanding of allergies, rooted in hypersensitive immune reactions to specific proteins, is paralleled by insights into sensitivities, which involve varied non-immunological responses. Ongoing and future research focuses on precision medicine, leveraging genomics for individualized treatment approaches. Immunotherapy innovations seek to enhance desensitization strategies, while microbiome research sheds light on the role of gut bacteria in shaping immune responses. Biomarker discovery, digital health solutions, and allergen-free food development contribute to comprehensive care. The exploration of epigenetics and environmental influences expands the horizon of causative factors. The holistic approach emphasizes patient education, advocacy, and interdisciplinary collaboration. As the field advances, the overarching goal is to improve the quality of life for individuals affected by these conditions, embracing technological innovations and fostering collaborative efforts in pursuit of personalized and precise management strategies.

Keywords: Food Allergies, Food Sensitivities, Immunological Response, Non-Immunological Response, Precision Medicine, Genomics, Immunotherapy, Microbiome, Biomarker Discovery, Digital Health

I.   Introduction

Food allergies and sensitivities constitute a growing health concern globally, impacting the lives of millions of individuals. These conditions manifest as adverse reactions to specific components

of various foods, creating a complex landscape of immune responses and physiological disruptions. The intricacies of food allergies and sensitivities involve diverse triggers, symptoms, and underlying mechanisms, making them a subject of intense scientific inquiry and public health attention [1].Food allergies, characterized by the immune system's hypersensitive response to certain proteins in food, can elicit a broad spectrum of reactions. From mild symptoms such as itching or hives to severe, life-threatening anaphylaxis, food allergies pose a significant health risk. Common allergens include peanuts, tree nuts, milk, eggs, soy, wheat, fish, and shellfish, each capable of triggering a unique immunological cascade in susceptible individuals. The prevalence of food allergies has risen in recent decades, prompting researchers and healthcare professionals to delve into the complexities of these reactions.Diagnosis of food allergies often involves allergen-specific testing, such as skin prick tests or blood tests, to identify specific triggers. Effective management primarily revolves around strict avoidance of the allergenic foods, coupled with education on recognizing and responding to allergic reactions. Epinephrine injectors are commonly prescribed for individuals with severe allergies, providing a crucial lifeline during emergencies[2].In parallel, food sensitivities represent a distinct category of adverse reactions, marked by non-immunological responses to certain foods. Unlike allergies, sensitivities do not trigger an immediate immune response but can lead to a range of symptoms, including gastrointestinal discomfort, headaches, or skin issues. Lactose intolerance, gluten sensitivity, and reactions to food additives exemplify common food sensitivities. Diagnosing sensitivities often involves specialized testing or elimination diets, with management strategies centering on avoiding trigger foods or substances[3].
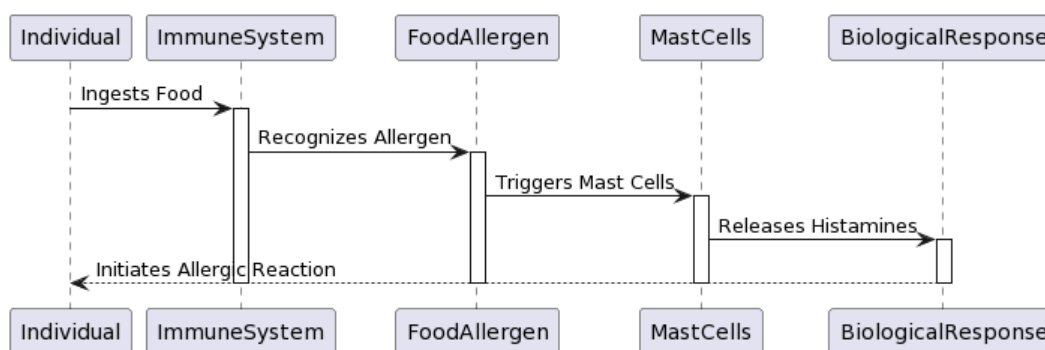

Figure 1. Depicts the Various Food Allergies in Human Body System

The management of both food allergies and sensitivities extends beyond medical interventions, permeating into daily life choices, dietary restrictions, and overall well-being. Individuals affected by these conditions often navigate a challenging terrain, requiring vigilance in food choices and heightened awareness of potential risks. Consequently, the psychological and social impacts of these conditions can be substantial, influencing individuals' relationships, mental health, and overall quality of life[4].Ongoing research in the field aims to unravel the intricate mechanisms underlying food allergies and sensitivities, seeking novel insights into diagnosis, treatment, and prevention. Immunotherapy, such as oral immunotherapy (OIT) and sublingual immunotherapy (SLIT), represents a promising frontier, with researchers exploring ways to desensitize individuals to specific allergens. Identifying biomarkers that can predict and diagnose food allergies is another active area of investigation, holding the potential to revolutionize early detection and personalized treatment approaches. In the realm of food sensitivities, the burgeoning field of microbiome research has gained prominence. Researchers are investigating the intricate relationship between the gut microbiome and sensitivities, exploring how modulation of the microbiota might influence allergic responses. Additionally, the low FODMAP (fermentable oligosaccharides, disaccharides, monosaccharides, and polyols) diet has emerged as a dietary intervention for managing sensitivities, focusing on reducing certain carbohydrates to alleviate symptoms [5]. Precision medicine, driven by advances in genomics, holds promise for tailoring treatment strategies based on an individual's genetic makeup and immune response. Understanding the role of the gut microbiome in food allergies and sensitivities paves the way for personalized dietary recommendations, emphasizing the intersection of genetics, immunology, and nutrition in managing these conditions.Technological advancements have played a pivotal role in the landscape of food allergies and sensitivities. Digital health solutions, including mobile applications and wearable devices, provide tools for tracking dietary habits, monitoring symptoms, and offering real-time assistance. These technologies not only empower individuals to manage their conditions but also contribute valuable data for research and healthcare professionals to enhance their understanding of these complex phenomena.Public awareness campaigns and educational initiatives have become integral components of addressing food allergies and sensitivities. Efforts to educate communities, schools, and workplaces about the prevalence, symptoms, and appropriate responses to allergic reactions aim to create inclusive and supportive environments [6]. These initiatives seek to dispel myths, reduce stigma, and

foster empathy, recognizing the diverse challenges individuals face in managing their dietary restrictions.Despite the progress in research and awareness, challenges persist in the realm of food allergies and sensitivities. Limited standardization of diagnostic procedures, varying degrees of awareness among healthcare professionals, and potential underreporting of cases contribute to the complexity of accurately gauging the prevalence and impact of these conditions. Additionally, the psychological burden on individuals, particularly children, dealing with dietary restrictions and the fear of allergic reactions necessitates a holistic approach to healthcare that encompasses mental well-being and social support.While significant strides have been made in understanding and managing food allergies and sensitivities, gaps in knowledge remain. Continued research efforts are crucial for unraveling the intricacies of these conditions, from uncovering novel therapeutic interventions to elucidating the environmental and genetic factors influencing their development [7]. Collaborative efforts between researchers, healthcare professionals, policymakers, and affected individuals are essential for fostering a comprehensive and empathetic approach to addressing the challenges posed by food allergies and sensitivities in diverse populations[8].

II.   Literature Review

The literature review encompasses a range of seminal studies that provide significant insights into the field of food allergies and related conditions. The study by Imamura et al. conducted a noteworthy survey in Japan, investigating the prevalence and characteristics of severe self-reported food allergies, contributing valuable epidemiological and clinical perspectives. Similarly, the exploration of food allergies in children in Singapore by Shek and Lee provides a regional understanding of allergic patterns[9]. Eriksson et al. extended this cross-cultural exploration by studying self-reported food hypersensitivity in multiple European countries, adding a nuanced layer to the understanding of regional variations in food hypersensitivity[10].The work of Sampson is pivotal, comprising a two-part series that extensively covers the immunopathogenesis, clinical disorders, diagnosis, and management of food allergies, serving as a foundational reference for researchers and clinicians alike. Sicherer and Sampson offered a comprehensive review of recent advances in food allergy research, presenting emerging trends and therapeutic strategies [11]. Nowak-Wegrzyn and Sampson's comprehensive review focuses on adverse reactions to foods, providing a broad-spectrum view

of reactions that guides clinicians in diagnosis and management.In the Annual Review of Nutrition, Lee and Burks contribute to the field by addressing the prevalence, molecular characterization, and treatment-prevention strategies of food allergies. Bock's prospective appraisal of complaints of adverse reactions to foods in young children, as published in Pediatrics, underscores the importance of longitudinal studies in understanding the onset and progression of food allergies [12]. Roehr et al. investigated food allergy and non-allergic food hypersensitivity in children and adolescents, providing insights into the prevalence and characteristics of food-related issues in pediatric populations[13].

Author & Year	Area	Methodology	Key Findings	Challenges	Pros	Cons	Application
Imamura et al. (2008)	Severe food allergies in Japan	Survey	Investigated prevalence and characteristics of severe self-reported food allergies in Japan.	- Limited generalizability outside Japan.	- Provides epidemiological insights.	- Relies on self-reporting.	Epidemiology and clinical understanding
Shek and Lee (1999)	Food allergies in children in Singapore	Not specified	Explored the landscape of food allergies in children in Singapore, contributing regional insights.	- Lack of detailed methodology description.	- Regional understanding of allergic patterns.	- Limited methodological transparency.	Regional patterns of food allergies
Eriks	Self-	Survey	Studied self-	- Varied	-	- Survey	Cross-

son et al. (2004)	reported food hypersensitivity		reported food hypersensitivity in several European countries, highlighting potential regional variations.	survey methodologies across countries.	Contributes to cross-cultural understanding.	design may introduce bias.	cultural variations in food hypersensitivity
Sampson (1999)	Immunopathogenesis and clinical disorders	Literature Review	Comprehensive two-part series on the immunopathogenesis, clinical disorders, diagnosis, and management of food allergies.	- Focuses on immunological aspects, limited on clinical management.	- Foundational reference for researchers and clinicians.	- Emphasis on immunology may limit practical applications.	Immunopathogenesis and clinical management of food allergies
Sicherer and Sampson (2009)	Recent advances in pathophysiology and treatment	Literature Review	A comprehensive review of recent advances in the pathophysiology and	- Primarily focused on recent advances, may lack	- Provides insights into emerging trends and therapeut	- May not cover all aspects of food allergy management.	Emerging trends and therapeutic strategies in food allergy

			treatment of food allergies.	historical context.	ic strategies.		
Nowak-Wegrzyn and Sampson (2006)	Adverse reactions to foods	Literature Review	Comprehensive review covering a broad spectrum of adverse reactions to foods, aiding in diagnosis and management.	- Limited focus on specific types of adverse reactions.	- Offers valuable information for diagnosing and managing food-related adverse events.	- May lack in-depth coverage of specific adverse reactions.	Diagnosis and management of various food-related adverse events
Lee and Burks (2006)	Prevalence, molecular characterization, and treatment-prevention strategies	Literature Review	A review addressing the prevalence, molecular characterization, and strategies for prevention and treatment of food allergies.	- Emphasis on molecular aspects, limited on prevention strategies.	- Contributes to understanding molecular basis and prevention strategies.	- Limited coverage on prevention may be a drawback.	Molecular characterization and prevention of food allergies
Bock (1987)	Prospective appraisal of complaints	Prospective Study	Prospective appraisal of complaints	- Limited to complain	- Lays the foundatio	- Focuses on early	Onset and progression of food

	of adverse reactions to foods in children		of adverse reactions to foods in children during the first three years of life.	ts in early childhood.	n for understanding early onset and progression of food allergies.	childhood, may not generalize to later ages.	allergies in early childhood
Roehr et al. (2004)	Food allergy and non-allergic food hypersensitivity in children and adolescents	Survey	Investigated the prevalence and characteristics of food allergy and non-allergic food hypersensitivity in children and adolescents.	- Limited by self-reporting and potential recall bias.	- Provides insights into prevalence and characteristics of food-related issues in pediatric populations.	- Relies on self-reporting, which may affect accuracy.	Prevalence and characteristics of food issues in pediatric populations
Rank et al. (2002	Management of eosinophilic esophagitis	Technical Review	Technical review on the management of eosinophilic esophagitis, providing	- Specialized focus on eosinophilic esophagitis.	- Valuable resource for clinicians dealing with this specific	- Limited to eosinophilic esophagitis, may not cover broader	Management of eosinophilic esophagitis

			guidance for clinicians.		condition.	aspects.	
Restani et al. (2009)	Meat allergy	Not specified	The specific methodology is not provided. Examined aspects related to meat allergy.	- Lack of detailed methodology description.	- Contributes to the understanding of meat allergy.	- Limited methodological transparency.	Understanding aspects related to meat allergy
Fischer et al. (2017)	Type I sensitization to alpha-gal	Not specified	The specific methodology is not provided. Investigated the prevalence of type I sensitization to alpha-gal in forest service employees and hunters.	- Lack of detailed methodology description.	- Provides insights into the prevalence of alpha-gal sensitization.	- Limited methodological transparency.	Prevalence of type I sensitization to alpha-gal
Villalta et al. (2016)	sIgE to galactose-α-1,3-galactose	Not specified	The specific methodology is not provided. Conducted a cross-sectional	- Lack of detailed methodology description.	- Highlights the high prevalence of sIgE to galactose	- Limited methodological transparency.	Prevalence of sIgE to galactose-α-1,3-galactose

			study on sIgE to galactose-α-1,3-galactose in a rural pre-Alps area.		-α-1,3-galactose.		
Shadick et al. (1999)	Exercise-induced anaphylaxis	Survey	Explored the natural history of exercise-induced anaphylaxis through survey results from a 10-year follow-up study.	- Relies on self-reported			

Table 1. Summarizes the Literature Review of Various Authors

III. Classification of Food allergies&Sensitivities

Food allergies and sensitivities represent adverse reactions to specific food components, but they vary in mechanisms and severity. Food allergies involve an immune response to certain proteins in food, which can lead to immediate reactions ranging from mild symptoms like hives to severe, life-threatening anaphylaxis. Common allergens include peanuts, tree nuts, milk, eggs, soy, wheat, fish, and shellfish. Diagnosis typically involves allergen-specific testing, and treatment often includes avoidance of the allergen and the use of epinephrine for severe reactions. Ongoing research explores immunotherapy and biomarker discovery to improve treatment and diagnosis. Food sensitivities don't involve the immune system's immediate response and may lead to delayed symptoms such as digestive issues, headaches, or skin problems. Common sensitivities

include lactose intolerance, gluten sensitivity, and reactions to food additives. Diagnosis often involves elimination diets or specific testing for sensitivities, and management usually requires avoiding trigger foods or substances. Research in this area focuses on understanding gut health, the role of the microbiome, and personalized nutrition to manage sensitivities effectively.

A. Food Allergies

Food allergies involve the immune system's hypersensitive response to specific proteins in certain foods. The body perceives these proteins as harmful, triggering an immune reaction.Common food allergens include peanuts, tree nuts, milk, eggs, soy, wheat, fish, and shellfish.

B. Symptoms:

Allergic reactions can range from mild, such as hives or itching, to severe, including anaphylaxis—a life-threatening response that requires immediate medical attention.

C. Diagnosis and Treatment:

Diagnosis involves allergen-specific testing, such as skin prick tests or blood tests. Treatment often includes avoidance of the allergen and the use of epinephrine for severe reactions.

D. Non-Immunological Response:

Unlike allergies, sensitivities don't involve the immune system's immediate response. Sensitivities can lead to various symptoms, such as digestive issues, headaches, or skin problems.

E. Common Sensitivities:

Examples include lactose intolerance, gluten sensitivity, and reactions to food additives.

F. Symptoms:

Symptoms may be delayed, making it challenging to pinpoint the exact cause of sensitivity.

G. Diagnosis and Management:

Diagnosis often involves elimination diets or specific testing for certain sensitivities. Management usually requires avoiding trigger foods or substances.

H. Research Focus Areas:

Current research explores the relationship between gut health and food sensitivities, examining factors like intestinal permeability and the gut microbiota. Additionally, the role of fermentable oligosaccharides, disaccharides, monosaccharides, and polyols (FODMAPs) in triggering symptoms is under investigation.

I. Future Directions:

Personalized nutrition based on individual sensitivities and tolerances may become more common, aided by advanced diagnostic tools. Probiotics and other microbial-based therapies are also being studied for their potential in managing symptoms associated with food sensitivities.

J. Digital Health Solutions:

Technology is increasingly used for tracking and managing both allergies and sensitivities, with apps and devices helping individuals monitor their food intake and symptoms.

K. Awareness and Education:

Public awareness campaigns and educational initiatives aim to improve understanding, diagnosis, and management of food allergies and sensitivities. Always consult with healthcare professionals for personalized advice and treatment.

Aspect	Food Allergies	Food Sensitivities
Immunological Response	Involves immune system hypersensitivity to specific food proteins.	Non-immunological response; does not involve the immediate immune system response.
Common Triggers	Peanuts, tree nuts, milk, eggs, soy, wheat, fish, shellfish.	Lactose, gluten, food additives, FODMAPs.
Symptoms	Range from mild (hives, itching) to severe (anaphylaxis).	Various symptoms, often delayed, including digestive issues, headaches, and skin problems.
Diagnosis	Involves allergen-specific	Often diagnosed through elimination

	testing (skin prick tests, blood tests).	diets or specific testing for certain sensitivities.
Treatment	Avoidance of allergens; use of epinephrine for severe reactions.	Avoidance of trigger foods or substances; symptom management.
Research Focus Areas	Immunotherapy (OIT, SLIT), biomarker identification.	Relationship between gut health and sensitivities; FODMAPs; personalized nutrition.
Future Directions	Personalized treatment based on genomics; gut microbiome research.	Advancements in personalized nutrition; exploration of microbial-based therapies.
Technology Trends	Increasing use of apps and devices for tracking and managing.	

Table 2. Comparative Evaluation of Different Food Allergies & Sensitivities

IV.   Current Search & Future Direction

A. Personalized nutrition based on individual sensitivities and tolerances may become more common, aided by advanced diagnostic tools. Probiotics and other microbial-based therapies are also being studied for their potential in managing symptoms associated with food sensitivities.

B. Advances in genomics and personalized medicine are expected to play a crucial role. Researchers aim to identify genetic markers associated with food allergies and sensitivities, leading to more precise and tailored treatment approaches based on an individual's genetic profile.

C. Immunotherapy continues to be a focal point, with ongoing efforts to refine existing approaches such as oral immunotherapy (OIT) and sublingual immunotherapy (SLIT). Future research may bring about more targeted and effective immunotherapeutic interventions to desensitize individuals and enhance their tolerance to specific food allergens.

D. Understanding the role of the gut microbiome in food allergies and sensitivities is an emerging area of interest. Researchers are exploring how the composition of gut bacteria

influences the development and management of food-related immune responses, potentially leading to therapeutic interventions that modulate the microbiome.

E. Efforts to identify reliable biomarkers for early detection and accurate diagnosis of food allergies and sensitivities are expected to intensify. Biomarkers could enhance diagnostic precision, enable personalized treatment plans, and facilitate the monitoring of treatment effectiveness.

F. The integration of technology, including mobile apps, wearables, and digital platforms, will likely continue to grow. These tools aim to assist individuals in tracking their dietary habits, symptoms, and potential triggers, providing valuable data for both patients and healthcare professionals to manage and understand food allergies and sensitivities.

G. In response to the increasing prevalence of food allergies, the food industry is likely to witness advancements in the development of allergen-free food products. Innovations in food processing and manufacturing may lead to safer and more accessible options for individuals with allergies and sensitivities.

H. Research exploring the role of epigenetics and environmental factors in the development of food allergies may provide new insights. Understanding how factors beyond genetics, such as environmental exposures, contribute to allergic responses could lead to more comprehensive preventive strategies.

I. As awareness of food allergies and sensitivities continues to grow, there will likely be an increased emphasis on patient education and advocacy. Empowering individuals with knowledge about their conditions, safe dietary practices, and available resources is crucial for effective management and improved quality of life.

V. Conclusion

In conclusion, the field of food allergies and sensitivities is undergoing dynamic advancements, driven by research, technological innovations, and a growing awareness of these conditions. The distinction between allergies and sensitivities, rooted in immunological and non-immunological responses, respectively, provides a nuanced understanding of adverse reactions to foods. As we look to the future, several key themes emerge.Precision medicine is poised to revolutionize the field, with ongoing efforts to identify genetic markers associated with food allergies and

sensitivities. This promises tailored treatment approaches, enhancing individualized care. Immunotherapy, a cornerstone in managing allergies, is subject to continuous refinement, aiming for targeted and effective interventions to enhance tolerance.Microbiome research introduces a novel dimension, exploring the intricate interplay between gut bacteria and food-related immune responses. Biomarker discovery remains pivotal, with the quest for reliable indicators driving early detection and precise diagnosis. Digital health solutions, from apps to wearables, empower individuals to monitor their dietary habits and symptoms, fostering proactive management.The food industry's response to the rising prevalence of allergies includes advancements in allergen-free food development, providing safer options for individuals with specific dietary restrictions. Exploring epigenetics and environmental influences broadens the understanding of factors contributing to these conditions. A holistic approach encompasses patient education, advocacy, and collaborative efforts among healthcare professionals. Empowering individuals with knowledge and fostering interdisciplinary collaboration are integral to achieving comprehensive insights and effective management.

References

[1] Imamura, T., Kanagawa, Y., &Ebisawa, M. (2008). A survey of patients with self-reported severe food allergies in Japan. Pediatric Allergy and Immunology, 19(4), 270-274.

[2] Shek, L. P., & Lee, B. W. (1999). Food allergy in children-the Singapore story. Asian Pacific Journal of Allergy and Immunology, 17(4), 203-206.

[3] Eriksson, N. E., Moller, C., Werner, S., Magnusson, J., Bengtsson, U., &Zolubas, M. (2004). Self-reported food hypersensitivity in Sweden, Denmark, Estonia, Lithuania, and Russia. Journal of Investigational Allergology and Clinical Immunology, 14(1), 70-79.

[4] Sampson, H. A. (1999). Food allergy. Part 1: Immunopathogenesis and clinical disorders. Journal of Allergy and Clinical Immunology, 103(Pt 1), 717-728.

[5] Sampson, H. A. (1999). Food allergy. Part 2: Diagnosis and management. Journal of Allergy and Clinical Immunology, 103, 981-989.

[6] Sicherer, S. H., & Sampson, H. A. (2009). Food allergy: recent advances in pathophysiology and treatment. Annual Review of Medicine, 60, 261-277.

[7] Nowak-Wegrzyn, A., & Sampson, H. A. (2006). Adverse reactions to foods. Medical Clinics of North America, 90, 97-127.

[8] Lee, L. A., & Burks, A. W. (2006). Food allergies: prevalence, molecular characterization, and treatment-prevention strategies. Annual Review of Nutrition, 26, 539-565.

[9] Bock, S. A. (1987). Prospective appraisal of complaints of adverse reactions to foods in children during the first 3 years of life. Pediatrics, 79, 683-688.

[10]   Roehr, C. C., Edenharter, G., Reimann, S., et al. (2004). Food allergy and non-allergic food hypersensitivity in children and adolescents. Clinical and Experimental Allergy, 34, 1534-1541.

[11]   Rank, M. A., Sharaf, R. N., Furuta, G. T., et al. (2020). Technical review on the management of eosinophilic esophagitis: a report from the AGA Institute and the joint task force on allergy-immunology practice parameters. Annals of Allergy, Asthma & Immunology, 124, 424–440.e17.

[12]   Restani, P., Ballabio, C., Tripodi, S., et al. (2009). Meat allergy. Current Opinion n Allergy and Clinical Immunology, 9, 265–269.

[13]   Fischer, J., Lupberger, E., Hebsaker, J., et al. (2017). Prevalence of type I sensitization to alpha-gal in forest service employees and hunters. Allergy, 72, 1540–1547.

[14]   Villalta, D., Pantarotto, L., Da Re, M., et al. (2016). High prevalence of sIgE to galactose-α-1,3-galactose in rural pre-Alps area: a cross-sectional study. Clinical and Experimental Allergy, 46, 377–380.

[15]   Shadick, N. A., Liang, M. H., Partridge, A. J., et al. (1999). The natural history of exercise-induced anaphylaxis: survey results from a 10-year follow-up study. Journal of Allergy and Clinical Immunology, 104, 123–127.

[16]   Robson-Ansley, P., Toit, G. D. (2010). Pathophysiology, diagnosis and management of exercise-induced anaphylaxis. Current Opinion in Allergy and Clinical Immunology, 10, 312–317.

[17]   Ma, S., Sicherer, S. H., Nowak-Wegrzyn, A. (2003). A survey on the management of pollen-food allergy syndrome in allergy practices. Journal of Allergy and Clinical Immunology, 112, 784–788.

[18]   Dhabliya, M. D., & Dhabalia, M. R. (2014). Object Detection and Sorting using IoT. International Journal of New Practices in Management and Engineering, 3(04), 01-04.

[19]   Verma, M. K., & Dhabliya, M. D. (2015). Design of Hand Motion Assist Robot for Rehabilitation Physiotherapy. International Journal of New Practices in Management and Engineering, 4(04), 07-11.

[20]   Khetani, V., Nicholas, J., Bongirwar, A., & Yeole, A. (2014). Securing web accounts using graphical password authentication through watermarking. International Journal of Computer Trends and Technology, 9(6), 269-274.

[21]   Bhattacharya, S., Rungta, D. S., & Kar, N. (2013). Intelligent Frequent Pattern Analysis in Web Mining. International Journal of Digital Application & Contemporary research, 2.

[22]   Limkar, S., Kulkarni, S., Chinchmalatpure, P., Sharma, D., Desai, M., Angadi, S., & Jadhav, P. (2020). Classification and Prediction of Rice Crop Diseases Using CNN and PNN. Intelligent Data Engineering and Analytics: Frontiers in Intelligent Computing: Theory and Applications (FICTA 2020), Volume 2, 1177, 31.

[23]   Mahajan, R. A., & Mahajan, S. A. (2020, March). Development of scrum-tree-KNN algorithm for distributed agile development. In 2020 International Conference on Emerging Smart Computing and Informatics (ESCI) (pp. 17-21). IEEE.