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The Differences in Repigmentation Rate Based on Location and Duration of Vitiligo Treatment in Pediatric Patients at Dermatology Venereology Outpatient Clinic of Dr. Moewardi Hospital

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Abstract

Background: Vitiligo is an acquired skin depigmentation disorder, mainly affecting children. It presents as a milky white macule or patch affecting one or several body areas. Due to the lack of consensus in treating vitiligo, the treatment still depends on the patient's clinical appearance and dermatologist's consideration. **Objectives:** This study aims to determine the differences in repigmentation rate based on location and duration of vitiligo treatment with the hope of providing a more efficient and targeted therapy plan in the future. **Methods:** This study used an observational analytical method with a prospective cohort approach in pediatric patients visiting the Dermatology and Venereology outpatient clinic of Dr. Moewardi Hospital in the period January 2023 to December 2024. The data were then tested using the Kruskall-Wallis and ANOVA test to compare variables with a significance level set at $p < 0.05$. **Results:** There were a total of 38 pediatric patients diagnosed with vitiligo, only 17 of whom met the inclusion criteria. The mean age of the subjects was 11.06 ± 3.96 years. Most of the samples were girls (58.8%). The average initial variance was 2.59 and the final variance was 0.80, thus the variance difference was 1.78 or overall repigmentation of 71.06%. The highest repigmentation rate was found in the trunk region (47,1%), followed by the face and neck (41,2%) and the palms and feet region (11,8%). There was a significant difference in the repigmentation rate between the trunk region and the palms and feet ($p = 0.036$). The duration of therapy did not show a significant difference with a p value of 0.850 ($p > 0.05$). **Conclusion:** There is a significant difference in the repigmentation rate between the trunk and palms and soles. The duration of therapy and the level of repigmentation are not significant.

Keywords: pediatric, repigmentation rate, vitiligo

Abstrak

Latar Belakang: *Vitiligo adalah kelainan depigmentasi kulit yang didapat (*acquired*), yang terutama menyerang anak-anak. Penyakit ini bermanifestasi sebagai makula atau bercak berwarna putih susu yang mengenai satu atau beberapa area tubuh. Akibat belum adanya konsensus dalam penanganan vitiligo, pengobatan masih bergantung pada gambaran klinis pasien dan pertimbangan dokter spesialis kulit.* ***Tujuan:*** *Penelitian ini bertujuan untuk mengetahui perbedaan tingkat repigmentasi berdasarkan lokasi dan durasi pengobatan vitiligo, dengan harapan dapat memberikan rencana terapi yang lebih efisien dan terarah di masa depan.* ***Metode:*** *Penelitian ini menggunakan metode observasional analitik dengan pendekatan kohort prospektif pada pasien anak yang mengunjungi poliklinik Dermatologi dan Venereologi RSUD Dr. Moewardi pada periode Januari 2023 hingga Desember 2024. Data kemudian diuji menggunakan uji Kruskal-Wallis dan ANOVA untuk membandingkan variabel dengan tingkat signifikansi yang ditetapkan pada $p < 0,05$.* ***Hasil:***

Terdapat total 38 pasien anak yang didiagnosis vitiligo, namun hanya 17 pasien yang memenuhi kriteria inklusi. Usia rata-rata subjek adalah 11,06 ± 3,96 tahun. Sebagian besar sampel adalah perempuan (58,8%). Rata-rata varians awal adalah 2,59 dan varians akhir adalah 0,80, sehingga selisih varians adalah 1,78 atau tingkat repigmentasi keseluruhan sebesar 71,06%. Tingkat repigmentasi tertinggi ditemukan pada area batang tubuh (47,1%), diikuti oleh wajah dan leher (41,2%) serta area telapak tangan dan kaki (11,8%). Terdapat perbedaan signifikan pada tingkat repigmentasi antara area batang tubuh dan area telapak tangan serta kaki (p = 0,036). Durasi terapi tidak menunjukkan perbedaan yang signifikan dengan nilai p sebesar 0,850 (p > 0,05). ***Kesimpulan:*** *Terdapat perbedaan signifikan pada tingkat repigmentasi antara area batang tubuh dan area telapak tangan serta kaki. Tidak terdapat perbedaan signifikan terkait durasi terapi terhadap tingkat repigmentasi.*

Kata kunci: *pediatrik, tingkat repigmentasi, vitiligo*

I. INTRODUCTION

Vitiligo is a skin depigmentation disorder characterized by the selective loss of melanocytes in the epidermal layer, resulting in the appearance of asymptomatic white macules that vary in shape and size.[1] Hypotheses regarding the mechanism of vitiligo include autoimmune, neurogenic, self-destruction mechanisms in the immune system, and external environmental exposure, such as trauma and sunlight.[2] This disease is more common in individuals with a family history of vitiligo.[3]

Worldwide, 0.24% of children have vitiligo.[4] Research by Irviani and Hapsari (2025) identified 105 new cases of vitiligo at Tarakan Regional General Hospital in Jakarta in 2023. Most patients were female (55.24%), and vitiligo vulgaris was the most common type (82.86%).[5]

Based on body region, pediatric vitiligo is classified as segmental, nonsegmental, or unclassified. Segmental vitiligo is characterized by one or more patches in a linear mosaic pattern or a unilateral dermatomal distribution, while nonsegmental vitiligo is defined as generalized or localized patches based on the affected area.[2]

Standard treatments for vitiligo include topical corticosteroids, topical calcineurin inhibitors, oral corticosteroids, phototherapy, and laser therapy.[6] Narrowband ultraviolet B (NB-UVB) is the phototherapy treatment of choice when topical treatments are ineffective or when there is extensive skin involvement. Children should not receive psoralen and ultraviolet A (PUVA) phototherapy because psoralen is systemically absorbed; NB-UVB is preferred for its superior efficacy.[7,8] NB-UVB administration may be associated with side effects such as erythema, itching, and a burning or mild pain sensation.[9] Another phototherapy option is monochromatic excimer light (CEM) at 308 nm. This modality is considered a primary treatment for vitiligo because of its good efficacy and limited side effects. However, there are currently no standard guidelines for the dose and frequency of CEM application for vitiligo treatment.[10,11]

Many clinicians believe that longer therapy duration leads to better repigmentation rates. This belief is inaccurate, as a study showed that repigmentation rates did not improve significantly after 12 months of phototherapy, and 3 months of therapy was also insufficient to demonstrate clinical improvement.[7,8]

This study aims to evaluate the level of repigmentation in pediatric patients with vitiligo and to analyze its relationship with lesion location and therapy duration.

II. METHODS

This study is an observational, analytical study with a prospective cohort design. Subjects included pediatric patients diagnosed with vitiligo from January 2023 to December 2024 who visited the Dermatovenereology outpatient clinic at Dr. Moewardi General Hospital, Surakarta. Collected demographic characteristics included gender, lesion distribution, duration of therapy, and repigmentation rate. Lesion distribution included the face and neck, trunk, and palms and soles. The repigmentation rate was assessed using the Vitiligo Area Scoring Index (VASI) before and after treatment. Data were analyzed using ANOVA for normally distributed data and the Kruskal-Wallis test for non-normally distributed data, with $p<0.05$ considered significant. Post hoc analysis of repigmentation rates by region, stratified by duration of therapy, was performed using the Mann-Whitney test, with results considered significant if $p<0.05$.

III. Result and Discussion

Based on the inclusion criteria, only 17 of 38 patients met the criteria. Most of the sample were girls (58.8%). The mean age of the subjects was 11.06 ± 3.96 years, with a minimum age of 4 years and a maximum age of 17 years. The mean initial Vitiligo Area Scoring Index (VASI) was 2.59, and the final VASI was 0.80, for a VASI difference of 1.78 (regression 71.06%). The most common location of vitiligo was the trunk (47.1%), followed by the face (41.2%) and the soles of the feet and palms of the hands (11.8%). The duration of therapy was mostly <12 months (41.2%), followed by 13-18 months (29.4%) and >19 months (29.4%) (Table 1).

The highest repigmentation rate for vitiligo was on the trunk, with an average of 85.09%, followed by the face and neck (65.59%) and the palms and soles (34.06%). Statistical analysis revealed a significant difference in repigmentation rates (%) based on vitiligo location, with a p-value of 0.045 ($p<0.05$) (Table 3). Meanwhile, based on the comparison of repigmentation rates between locations, there was no significant difference between the face and neck and the trunk (65.59% vs. 85.09%) with a p-value of 0.102 ($p>0.05$) or between the face and neck and the palms and soles (65.59% vs. 34.06%) with a p-value of 0.142 ($p>0.05$). A significant difference in repigmentation rate was observed between the trunk and the palms and soles (85.09% vs. 34.06%) with a p-value of 0.036 ($p<0.05$) (Table 5). The repigmentation rate (%) based on therapy duration also did not show a significant difference, with a p-value of 0.850 ($p>0.05$) (Table 6).

Tabel 1. Demographic Characteristics of Research Subjects

	N	Mean	Std Deviation	Median	Minimum	Maximum
Age	17	11.06	3.96	10.00	4.00	17.00
Gender						
Men	7	41.2%				
Women	10	58.8%				
Initial VASI	17	2.59	1.80	2.50	0.15	7.00
Final VASI	17	0.80	0.92	0.50	0.00	3.50
Delta VASI	17	1.78	1.27	1.75	0.14	3.69
Rate of Repigmentation	17	71.06	25.34	75.06	18.11	100.00
Vitiligo site						
Face and neck	7	41.2%				
Trunk	8	47.1%				
Palms and soles	2	11.8%				
Therapy duration						
<12 months	7	41.2%				
13-18 months	5	29.4%				
>19 months	5	29.4%				

Table 2. Normality Test of Repigmentation Rate (%) Based on Vitiligo Site

Vitiligo site	Saphiro-Wilk			Description
	Statistic	df	p-value	
Face and neck	0.897	7	0.315	Normal
Trunk	0.760	8	0.011	Not normal
Palms and soles	n/s	2	n/s	Not normal

The data are considered normal if $p > 0.05$.

Table 3. Repigmentation Rate (%) Based on Vitiligo Site

Vitiligo Site	Repigmentation Rate (%)						
	N	Mean	Std. Deviation	Median	Minimum	Maximum	P-Value
Face and neck	7	65.59	26.77	60.00	33.33	100.00	0.045 *
Trunk	8	85.09	11.59	78.89	75.00	100.00	
Palms and soles	2	34.06	22.55	34.06	18.11	50.00	

Kruskal-Wallis test (data not normally distributed),

*significant at p<0.05

TABLE 4. POST HOC OF REPIGMENTATION RATE (%) BASED ON VITILIGO SITE

Vitiligo	Mean of Repigmentation rate	P-Value
Face and neck vs Trunk	65.59 vs 85.09	0.102
Face and neck vs Palms and soles	65.59 vs 34.06	0.142
Trunk vs Palms and soles	85.09 vs 34.06	0.036*

Post Hoc Mann Whitney (data not normally distributed); *significant at p<0.05

TABLE 5. NORMALITY RATE OF REPIGMENTATION RATE (%) BASED ON VITILIGO SITE

Therapy duration	Saphiro-Wilk			Description
	Statistic	df	p-value	
<12 months	0.870	7	0.187	
13-18 months	0.868	5	0.258	
>19 months	0.948	5	0.719	

The data is considered normal if p>0.05

TABLE 6. REPIGMENTATION RATE (%) BASED ON THERAPY DURATION

Therapy duration	Repigmentation Rate (%)						
	N	Mean	Std. Deviation	Median	Minimum	Maximum	P-Value
<12 mo	7	69.85	33.19	75.00	18.11	100.00	0.850
13-18 mo	5	76.57	26.58	77.78	33.33	100.00	
>19 mo	5	67.24	12.25	70.00	50.00	80.00	

Anova test (data normally distributed); *significant at p<0.05

Vitiligo is a dermatological disorder characterized by depigmented macules resulting from the loss of functional melanocytes. Vitiligo lesions can cause significant aesthetic disturbances, potentially leading to psychological effects, especially in children.[8] Vitiligo can occur in all age groups, but the disease shows a bimodal pattern, with early onset at 7.3 years of age and late onset around 40.5 years of age.[7] Vitiligo that occurs in childhood is defined as disease onset before age 12. This condition has several characteristics that distinguish it from vitiligo in adults. In children, vitiligo tends to be more segmental, is often associated with allergic diseases, and shows a stronger association with autoimmune background and family history.[8]

The average age of patients in this study was 11.06 years, indicating that most patients were pre-adolescents or early adolescents. This finding is consistent with a 2023 study by Hasan et al. in Bangladesh, which reported that vitiligo was most common in the 11-20 age group (27.3%).[9] The 11-20 age group had a high incidence of vitiligo, presumably due to genetic factors, including increased expression of Human Leukocyte Antigen DR Beta 4 (HLA-DR4). This condition triggers the formation of autoantigens in T cells, which then induce an immune response in the form of autoantibody production and autoreactive cells, leading to melanocyte damage.[10]

The prevalence of vitiligo in this study was higher in girls (58.8%) than in boys (41.2%). This finding aligns with a systematic review by Farajzadeh et al. In 2023, which reported that vitiligo cases were more prevalent in girls. This is likely influenced by social factors, as girls tend to seek treatment sooner because vitiligo lesions are perceived to interfere with aesthetics and overall appearance.3 Vitiligo is also often associated with a higher prevalence of autoimmune conditions in women, although the pathogenesis of both is not yet fully understood. Vitiligo is more common in people with a family history of vitiligo.[3]

Vitiligo is classified based on the distribution, pattern, and degree of depigmentation into non-segmental and segmental types. The non-segmental type includes localized, generalized, and universal types. The localized type includes focal and segmental types. The generalized type includes acrofacial (face and distal extremities), vulgaris (symmetric distribution of lesions), and

mixed (a combination of segmental with vulgaris or acrofacial). The final classification of vitiligo is the universal type, which involves lesions covering more than 80% of the entire body surface area.[11]

Vitiligo is a multifactorial, polygenic disorder with complex pathophysiology that remains incompletely understood. This condition involves both genetic and non-genetic factors. The hallmark of vitiligo is the absence of melanocytes, which causes progressive skin depigmentation. Several theories have been proposed to explain the mechanism of melanocyte destruction, including cytotoxic mechanisms, autoimmune mechanisms, intrinsic melanocyte defects, neural mechanisms, and oxidant–antioxidant mechanisms. The neural hypothesis states that neurochemical mediators can damage melanocytes and reduce melanin production. The oxidant-antioxidant theory suggests that byproducts of melanin synthesis contribute to melanocyte damage. The intrinsic melanocyte defect theory argues that there is a congenital abnormality in melanocytes that inhibits growth and differentiation. The autoimmune or cytotoxic hypothesis is the most widely supported, especially in non-segmental vitiligo, where changes in the humoral and cellular immune systems are thought to cause melanocyte dysfunction or destruction. This type is also more commonly associated with other autoimmune diseases than segmental vitiligo.[3,12–15]

Vitiligo generally affects areas exposed to sunlight and those that are normally more pigmented, such as the face, back of the hands, areola mammae, axilla, umbilicus, and genitalia.[16] Previous research by Adnyasitarini et al. in 2023 reported that the face is the most common location for vitiligo in children (21.42%).[17] The face is the most affected location due to constant sun exposure and higher melanocyte activity. Vitiligo lesions on the extremities often appear due to the Köebner phenomenon, in which depigmentation follows skin trauma.[16] The findings in this study show that vitiligo lesions were most found on the trunk (47.1%), while the face and neck were in second place (41.2%). The difference between the two locations was limited to one subject, so the distributions can be considered relatively similar, although this difference may have been influenced by the relatively small sample size in this study. The predominance of trunk lesions in this study may reflect individual variations in lesion distribution or the presence of other triggering factors, such as clothing habits, friction, or minor trauma, that contribute to the onset of vitiligo.

The mean initial VASI score in this study was 2.59, and the final VASI score decreased to 0.80, yielding a VASI difference of 1.78. This decrease reflects a repigmentation rate of 71.06%, indicating a good therapeutic response in the pediatric population. These findings indicate that the effectiveness of therapy in this study was higher than in several previous studies. A study by Praditpa et al. in 2023 reported an average VASI reduction of 18% after 36 phototherapy sessions and 22% after 48 sessions, with the most significant reduction of 66.25% after 36 phototherapy sessions in adult patients with a facial and acral extremity predilection.[16] A meta-analysis by Mohammed et al. in 2025 in Hungary showed an average VASI improvement of 43.8% with topical Janus Kinase (JAK) inhibitor use and an increase in repigmentation of 48.7–63.7% in combination with NB-UVB phototherapy.[18] Findings from the study by Ezzedine et al. in 2025 confirmed that a 30% and 50% reduction in VASI scores already reflects clinically meaningful repigmentation.[19] Therefore, the

improvement in VASI scores in this study can be categorized as clinically meaningful, even exceeding the minimum threshold considered clinically significant in previous studies.

The management of vitiligo involves individualized approaches and factors that influence treatment selection, including disease duration, skin type, age, area of skin involved, and social and cultural factors. The goals of vitiligo therapy are to reduce melanocyte stress, regulate the immune response, stimulate melanocyte regeneration, and improve quality of life. Therapeutic modalities for vitiligo include topical corticosteroids, topical calcineurin inhibitors, NB-UVB and PUVA phototherapy, excimer light, oral steroids, and surgical procedures.[11]

Previous systematic reviews have shown that the face and neck are the most responsive areas to therapy. However, in this study, combining potent topical steroid therapy with NB-UVB targeting the face, neck, extremities, and palms and soles produced less significant repigmentation, with an average response rate below 75%. The highest repigmentation rate was observed in the trunk, at 85.09%. This can be explained by several anatomical and physiological factors. The trunk is a hairy area and therefore has a large reserve of melanocyte stem cells. These stem cells are mainly found in hair follicles, namely in the bulge, outer root sheath, and hair bulb.[20,21] The presence of these melanocyte precursors is very important in supporting the repigmentation process after therapy. The palms of the hands and soles of the feet do not have hair follicles, so they have few or no reserves of melanocyte stem cells, which contributes to the low level of repigmentation. The skin on the trunk is also thinner than that of the acral areas. This difference in thickness facilitates phototherapy penetration and enhances the activation of residual melanocytes by UV radiation.[22] Immunoregulation also influences treatment outcomes. Memory T cells residing in vitiligo lesions play a role in inhibiting repigmentation.[23] The trunk also has technical advantages, as it is easily accessible and has a relatively flat surface.[24] These characteristics allow for uniform and consistent application of phototherapy. UV exposure, the gold standard for melanocyte activation, can be optimally delivered in this area.[23] The combination of these factors supports the high repigmentation rate in the trunk region in this study.

Topical therapy is often used for vitiligo affecting less than 5% of the body surface area, either alone or in combination with phototherapy. The main treatments include topical corticosteroids and calcineurin inhibitors. Corticosteroids such as clobetasol propionate are effective, affordable, and easy to apply, but they can cause side effects such as skin thinning and increased eye pressure. These corticosteroids are best used in treatment cycles, and options with moderate potency, such as mometasone, are recommended for children. Calcineurin inhibitors are effective and safer for sensitive areas such as the face, neck, and skin folds, especially in children. Although there are concerns about the risk of cancer with long-term use, current evidence does not support an increased risk with topical application.[25]

Phototherapy is the primary treatment for extensive vitiligo that cannot be managed with topical therapy alone. Narrowband Ultraviolet B (NB-UVB) is the preferred option for adults and children because of its superior efficacy and safety compared with PUVA, especially in patients with darker skin types.[26] NB-UVB phototherapy is recommended for extensive vitiligo or cases that significantly impact quality of life. Treatment often requires at least six months to assess effectiveness, and

progress should be monitored with photos every 2–3 months.[7,8,17] Narrowband UVB is the first-line modality for vitiligo therapy in lesions covering >15–20% of the body surface area or in rapidly progressive forms. The Vitiligo Working Group recommends an optimal frequency of NB-UVB phototherapy of three times per week, with treatment outcomes evaluated after 18–36 sessions and a minimum of 72 sessions before discontinuing therapy. This is because a delayed response is possible. There is no maximum limit on the number of sessions for patients with phototypes IV–VI. The maximum acceptable dose is 1,500 mJ/cm² for the face and 3,000 mJ/cm² for the body.[27] Lopez et al. recommend an initial dose of 200 mJ/cm² regardless of the patient's skin phototype. The dose is increased by 10–20% per session until mild erythema that resolves within <24 hours is achieved. The dose can be gradually increased again after the erythema subsides.[28] NB-UVB can be combined with systemic corticosteroids, and an initial dose of 100 mJ/cm² is used to prevent the Koebner isomorphic phenomenon in rapidly progressive vitiligo.[29]

NB-UVB phototherapy directly stimulates melanocyte precursors in the hair follicle bulge. Laser capture microdissection studies have shown a 3.2-fold increase in the transcription factor Glioma-associated oncogene 1 (GLI-1) and activation of the β-catenin pathway in these bulge stem cells after NB-UVB exposure. This pathway is important for melanocyte differentiation and migration, so its reactivation mobilizes progenitor cells, specifically melanoblasts, which migrate from the hair follicles to the depigmented epidermis and induce melanogenesis by increasing tyrosinase expression and melanin production in reactivated melanocytes. NB-UVB phototherapy also induces structural changes that support melanocyte function, including an average epidermal thickening of 0.15 mm after treatment, creating a supportive microenvironment. This also enhances keratinocyte signaling by increasing the secretion of basic fibroblast growth factor (bFGF) and endothelin, both of which promote melanocyte proliferation and dendrite formation.[3,15]

PUVA therapy may be considered for adults when NB-UVB is unavailable or ineffective, despite its greater number of side effects. Targeted phototherapy and laser treatments, such as excimer laser, may be useful for localized lesions. Patients should be informed that phototherapy may tan normal skin in the surrounding area, temporarily making vitiligo patches more visible.[7,8,17]

The duration of treatment can also contribute to the success of therapy. The effects of phototherapy can usually be achieved within a minimum treatment period of six months. A meta-analysis revealed that patients who received phototherapy for three months had minimal response, leading to the conclusion that three months of phototherapy is not sufficient to treat vitiligo.[7] One year is the ideal duration to achieve the best results. Phototherapy administered for longer than one year in some patients did not produce satisfactory results compared with those who received therapy for less than one year.[16] In this study, the best therapeutic response was obtained in subjects who had undergone therapy for almost one year. The administration of a combination therapy of potent topical steroids and targeted NB-UVB for more than 18 months did not provide a superior therapeutic response compared with subjects who underwent therapy for less than one year. This phenomenon can be explained by a possible plateau effect in phototherapy. The plateau effect is defined as a condition

in which there is no significant repigmentation after >20 consecutive NB-UVB exposures. The skin tends to decrease sensitivity to UV exposure, so prolonging therapy is no longer effective at this stage. A temporary cessation of therapy for 3-6 months is necessary to restore the effects of phototherapy. Phototherapy can be restarted after cessation, with the initial dose starting from the Minimal Erythema Dose (MED).[29] Regardless of the duration of phototherapy, this study did not include the regularity of phototherapy administration, which may play a role in increasing the level of repigmentation. A study by Wang et al. in 2023 stated that there was no difference in repigmentation rates between patients who received phototherapy twice a week and once a week. An increase in repigmentation rates was obtained with longer durations of phototherapy. Consideration of other modalities such as skin grafts may be recommended for patients with stagnant repigmentation rates.[30]

IV. CONCLUSION

In this study, the highest level of vitiligo repigmentation was observed in the trunk region. Significant differences in repigmentation levels were observed between the trunk and the palms of the hands and the soles of the feet. In pediatric patients at the dermatovenerology outpatient clinic of Dr. Moewardi General Hospital, the duration of therapy and repigmentation levels were not significantly related.

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DAFTAR PUSTAKA

[1]. Seneschal J. Clinical features of vitiligo and social impact on quality of life. Dermatol Pract Concept. 2023;13(4 Suppl 2):e2023312S.
[2]. Marchioro HZ, de Castro CCS, Fava VM, Sakiyama PH, Dellatorre G, Miot HA. Update on the pathogenesis of vitiligo. An Bras Dermatol. 2022;97(4):478–90.
[3]. Farajzadeh S, Khalili M, Mirmohammadkhani M, Paknazar F, Rastegarnasab F, Abtahi-Naeini B. Global clinicoepidemiological pattern of childhood vitiligo: a systematic review and meta-analysis. BMJ Paediatr Open. 2023;7(1):e001839.
[4]. Akl J, Lee S, Ju HJ, Parisi R, Kim JY, Jeon JJ, et al. Estimating the burden of vitiligo: a systematic review and modelling study. Lancet Public Health. 2024;9(6):e386–96.
[5]. Irviani I, Hapsari SRA. Deskripsi Profil Pasien Baru Vitiligo di Rumah Sakit Umum Daerah Tarakan Jakarta Periode Tahun 2023. Jurnal MedScientiae. 2025;4(1).
[6]. Yousefian F, Yadlapati S, Browning JC. The use of Janus kinase inhibitors and narrowband ultraviolet B combination therapy in non-segmental vitiligo. J Cosmet Dermatol. 2023;22(3):1105–7.
[7]. Bishnoi A, Parsad D. Phototherapy for vitiligo: A narrative review on the clinical and molecular aspects, and recent literature. Photodermatol Photoimmunol Photomed. 2024;40(3):e12968.
[8]. Myers E, Kheradmand S, Miller R. An update on narrowband ultraviolet B therapy for the treatment of skin diseases. Cureus. 2021;13(11).
[9]. Garza-Mayers AC, Paquette GM, Harris JE, Wiss K. Narrowband ultraviolet B phototherapy in pediatric vitiligo: A retrospective study. J Am Acad Dermatol. 2023;89(1):135–6.
[10]. Wang JY, Yao SL, Hou XY, Xiao HL, Lu B. Weekly phototherapy is an effective therapy for patients with vitiligo. Medicine International. 2023;3(6):58.
[11]. Moghadam PM, Rasouli SR, Gheybi F, Karimi E, Sahebkar AH. A comprehensive review on present and future of pharmacotherapy of vitiligo disease and potential therapeutic strategies. Phytomedicine Plus. 2023;3(2):100437.
[12]. Lee Y ji, Lee Y, Kim MS, Lew BL, Kwon SH. Similar seasonality in childhood-onset, pediatric, and adulthood-onset vitiligo: a common data model analysis of 16 real-world databases. Ann Dermatol. 2024;36(5):326.
[13]. Jin Y, Santorico SA, Spritz RA. Pediatric to adult shift in vitiligo onset suggests altered environmental triggering. Journal of Investigative Dermatology. 2020;140(1):241–3.
[14]. Hasan MR, Ahmad GKA, Ahmed MR, Rahman MT, Nahid A, Islam S, et al. Clinico-

epidemiological characteristics of patients with vitiligo in Bangladesh. JAAD Int. 2023;13:1–3.
[15]. Faraj S, Kemp EH, Gawkrodger DJ. Patho-immunological mechanisms of vitiligo: the role of the innate and adaptive immunities and environmental stress factors. Clin Exp Immunol. 2022;207(1):27–43.
[16]. AL-smadi K, Imran M, Leite-Silva VR, Mohammed Y. Vitiligo: a review of aetiology, pathogenesis, treatment, and psychosocial impact. Cosmetics. 2023;10(3):84.
[17]. Eleftheriadou V. Reliability and validity of the Vitiligo Signs of Activity Score. British Journal of Dermatology. 2020;183(5).
[18]. Joge RR, Kathane PU, Joshi SH. Vitiligo: a narrative review. Cureus. 2022;14(9).
[19]. Dellatorre G, Fava VM, Mira MT, de Castro CCS. Experimental approaches to assess melanocytes mosaicism in segmental vitiligo. An Bras Dermatol. 2023;98(2):216–20.
[20]. Hu Z, Wang T. Beyond skin white spots: vitiligo and associated comorbidities. Front Med (Lausanne). 2023;10:1072837.
[21]. Albelowi LM, Alhazmi RM, Ibrahim S. The pathogenesis and management of vitiligo. Cureus. 2024;16(12).
[22]. Pradipta NK, Ryoto V, Danarti R, Budiyanto A. Characteristics and decreased Vitiligo Area Scoring Index of vitiligo patients with narrowband-UVB phototherapy in Yogyakarta, Indonesia. Dermatol Reports. 2023;15(4):9708.
[23]. Adnyasitarini MS, Rosvanti TIA, Silayukti AAAAK, Dewi AAIS. Clinico-epidemiology vitiligo profile in childhood at Mangusada General Hospital Badung. Intisari Sains Medis. 2023;14(3):1049–52.
[24]. Mohammed AA, Lengyel AS, Meznerics FA, Szondy I, Walter A, Szabó B, et al. Efficacy and safety of JAK inhibitors in the management of vitiligo: A systematic review and meta-analysis. Dermatol Ther (Heidelb). 2025;15(7):1657–79.
[25]. Ezzedine K, Soliman AM, Camp HS, Ladd MK, Pokrzywinski R, Coyne KS, et al. Psychometric properties and meaningful change thresholds of the vitiligo area scoring index. JAMA Dermatol. 2025;161(1):39–46.
[26]. Chakraborty AS, Agarwal R, Preethi P, Chandrashekar BS. Clinico-Epidemiological Profile of Childhood Vitiligo. Indian Dermatol Online J. 2024;15(4):683–4.
[27]. Kubelis-López DE, Zapata-Salazar NA, Said-Fernández SL, Sánchez-Domínguez CN, Salinas-Santander MA, Martínez-Rodríguez HG, et al. Updates and new medical treatments for vitiligo. Exp Ther Med. 2021;22(2):1–11.
[28]. Huang L, Zuo Y, Li S, Li C. Melanocyte stem cells in the skin: Origin, biological characteristics, homeostatic maintenance and therapeutic potential. Clin Transl Med. 2024;14(5):e1720.
[29]. Anbar T, Abdelraouf H, Afify AAE, Ragaie MH, Eid AA, Moneib H. Videodermoscopic changes of the hair in vitiligo lesions in relation to disease duration. Dermatol Pract Concept. 2022;12(4):e2022163.
[30]. Shah F, Giri PS, Bharti AH, Dwivedi M. Compromised melanocyte survival due to decreased suppression of CD4+ & CD8+ resident memory T cells by impaired TRM-regulatory T cells in generalized vitiligo patients. Exp Dermatol. 2024;33(1):e14982.