CHARACTERISTICS OF BODY WEIGHT CHANGES IN PEDIATRIC TUBERCULOSIS RECEIVING ANTI-TUBERCULOSIS DRUGS AT PROF. DR. I.G.N.G. NGOERAH GENERAL HOSPITAL FROM 2021 TO 2024

Ni Komang Ayu Renita Dewi[1*], Ayu Setyorini Mestika Mayangsari[2], I Gusti Ayu Putu Eka Pratiwi[3], I Wayan Gustawan[4]
Medical Student, Faculty of Medicine, Udayana *University*[1], *Departement of Pediatrics, Faculty of Medicine,* Udayana *University*, Prof. Dr. I.G.N.G. Ngoerah Hospital, Bali, Indonesia[2,3,4]
**Corresponding Author :* ayu.renita@student.unud.ac.id

ABSTRAK
Penurunan berat badan merupakan salah satu gejala klinis yang umum pada anak penderita tuberkulosis (TB). Pemberian obat antituberkulosis (OAT) diharapkan tidak hanya menekan infeksi tetapi juga mendorong penambahan berat badan pada anak. Efektivitas pengobatan TB pada anak dapat dievaluasi melalui perbaikan gejala klinis dan penambahan berat badan. Namun, literatur tentang perubahan berat badan pada anak selama pengobatan TB masih terbatas. Penelitian ini bertujuan untuk mengetahui karakteristik perubahan berat badan pada pasien TB anak yang menerima OAT di RSUP Prof. Dr. I.G.N.G. Ngoerah. Penelitian ini merupakan penelitian deskriptif analitik dengan pendekatan potong lintang. Data dikumpulkan secara retrospektif menggunakan teknik total sampling melalui rekam medis dan registri pasien TB anak dari tahun 2021 hingga 2024. Analisis univariat dan bivariat digunakan dalam penelitian ini. Sebanyak 26 pasien TB anak berusia 0–18 tahun diikutsertakan, dengan mayoritas berusia 10–18 tahun dan proporsi perempuan yang sedikit lebih tinggi. Semua anak mengalami penambahan berat badan selama terapi OAT. Berat badan rata-rata meningkat secara signifikan di seluruh tahapan pengobatan (dari 28,75±11,94 kg menjadi 36,54±14,28 kg; p<0,001), dengan pertambahan tertinggi diamati selama fase intensif. Status gizi juga membaik secara signifikan, sebagaimana ditunjukkan oleh pergeseran skor-z rata-rata IMT/U dari rentang kurus parah menjadi normal (p<0,001). Terdapat peningkatan berat badan yang signifikan dan perbaikan status gizi pada akhir fase intensif dan fase lanjutan dibandingkan dengan awal pengobatan.

Kata kunci **:** berat badan, obat antituberkulosis, RSUP Prof. Dr. I.G.N.G. Ngoerah, status gizi, tuberkulosis anak

ABSTRACT
Weight loss is one of the common clinical symptoms in children with tuberculosis (TB). The administration of anti-tuberculosis drugs (ATD) is expected not only to suppress the infection but also to promote weight gain in children. The effectiveness of TB treatment in children can be evaluated through the improvement of clinical symptoms and weight gain. However, the literature on weight changes in children during TB treatment is still limited. This study aims to determine the characteristics of weight changes among pediatric TB patients receiving ATD at Prof. Dr. I.G.N.G. Ngoerah General Hospital. Descriptive analytical study using a cross-sectional approach. Data were collected retrospectively using total sampling techniques through medical records and the pediatric TB patient registry from 2021 to 2024. Univariate and bivariate analysis was used in this study. A total of 26 pediatric TB patients aged 0–18 years were included, with the majority aged 10–18 years and a slightly higher proportion of females. All children experienced weight gain during ATD therapy. The mean body weight increased significantly across treatment stages (from 28.75 ± 11.94 kg to 36.54 ± 14.28 kg; $p < 0.001$), with the highest gain observed during the intensive phase. Nutritional status also improved significantly, as indicated by a shift in mean BMI-for-age z-scores from the severe thinness range to normal ($p < 0.001$). There was a significant increase in body weight and improvement in nutritional status by the end of the intensive phase and continuation phase compared to the start of treatment.

Keywords ***:*** *pediatric tuberculosis, body weight, nutritional status, anti-tuberculosis drugs, RSUP Prof. Dr. I.G.N.G. Ngoerah*

INTRODUCTION

Tuberculosis (TB) is an infectious disease that has remained a global health concern. In 1993, the World Health Organization (WHO) declared TB a global emergency. Although TB treatment has evolved, no country has eliminated this infection. TB is caused by *Mycobacterium tuberculosis* (MTB), which most commonly affects the lungs and spreads through the air when a TB patient coughs or sneezes. WHO data shows that each year, 10 million people are infected with TB, and 1.5 million TB patients die annually (WHO, 2022; Kumar et al., 2023). Indonesia is the second country with the highest TB incidence rate in the world. The Ministry of Health of the Republic of Indonesia reported that the total number of TB cases recorded in Indonesia in 2023 was 821,200, with 136,969 of these being pediatric TB cases. TB is a major health issue for all age groups, and among the total TB burden, children are the most vulnerable group to experience poor clinical outcomes. Symptoms experienced by TB patients include coughing, fever, and weight loss. Among these symptoms, weight loss is commonly found in the pediatric population. Weight loss in TB patients is caused by decreased appetite, malabsorption of macronutrients and micronutrients, and metabolic changes. This makes children with TB vulnerable to malnutrition (CDC, 2024; Kemenkes, 2024; WHO, 2024).

TB causes nutritional status disorders due to massive production of inflammatory mediators and a decrease in leptin hormone levels. Leptin is a hormone that plays a role in regulating body weight and cellular immunity. Meanwhile, malnutrition can weaken the immune system and worsen the progression of TB. Administration of anti-tuberculosis drugs (ATD) reduces the acute phase response in TB patients, accompanied by improvement and increased leptin concentration. The increase in leptin levels in TB patients during treatment plays a crucial role in stimulating appetite and weight gain. Therefore, the effectiveness of TB treatment is not only evaluated based on clinical symptom improvement or laboratory results but also on weight gain, which can be assessed through anthropometric measurements (Mexitalia et al., 2017; Padmapriyadarsini et al., 2016).

Although Mexitalia et al. (2017) reported increases in leptin levels, body weight, and body fat percentage in children after TB treatment, literature on weight gain in the pediatric TB population receiving ATD remains limited, particularly at tertiary hospitals such as Prof. Dr. I.G.N.G. Ngoerah General Hospital. However, body weight is an important clinical parameter that can reflect children's response to treatment and nutritional status during therapy. Therefore, the authors were interested in conducting a study on "Characteristics of Body Weight Changes in Children with Tuberculosis Receiving Anti-Tuberculosis Drugs (ATD) at Prof. Dr. I.G.N.G. Ngoerah General Hospital from 2021 to 2024".

This study aims to determine the characteristics of weight changes among pediatric TB patients receiving ATD at Prof. Dr. I.G.N.G. Ngoerah General Hospital.

METHODS

This was a descriptive analytical study with a cross-sectional design. Data were collected retrospectively from secondary sources (medical records and pediatric TB registry data). A total sampling technique was applied to include all eligible subjects who met the inclusion criteria. The criteria that subjects had to meet were: children aged 0-18 years diagnosed with active TB, receiving ATD at Prof. Dr. I.G.N.G. Ngoerah General Hospital between 2021 and 2024, and having complete medical records including: age, gender, type of TB, contact history, BCG vaccination, clinical manifestations, laboratory test results, radiological findings, TB case status, comorbidities, height, and weight. Exclusion criteria in this study include incomplete, damaged, or missing medical records, pediatric TB patients diagnosed with latent TB, and died

before or during the ATD treatment period. The variables identified in this study include age, gender, type of TB, TB contact history, BCG vaccination history, clinical manifestations, GeneXpert test results, AFB smear results, TST results, chest X-ray results, TB case status, comorbidities, nutritional status, and body weight.

The nutritional status of children in this study was assessed using BMI for Age z-score, calculated with WHO Anthro and WHO AnthroPlus software. Nutritional status was evaluated at three points: the start of treatment, the end of the intensive phase, and the end of the continuation phase, to analyze trends in nutritional changes during ATD therapy. Body weight was also measured at the same points to assess patterns of weight gain throughout the treatment. Data were analyzed using SPSS version 29.0. Univariate analysis was used for data description, and bivariate analysis was used to compare weight between measurement times and BMI-for-age z-scores between measurement times, with $p < 0.05$ considered as significant. This study has been approved by the Ethics Committee of the Faculty of Medicine, University of Udayana/Prof. Dr. I.G.N.G. Ngoerah General Hospital No: 2949/UN.14.2.2.VII.14/LT/2024.

RESULTS

A total of 64 pediatric TB cases were recorded between 2021 and 2024 at Prof. Dr. I.G.N.G. Ngoerah General Hospital. However, only 26 met the inclusion criteria and had complete weight measurements at the start of treatment, the end of the intensive phase, and the continuation phase, making them eligible for analysis.

Table 1. Demographic and Clinical Characteristics of Pediatric Tuberculosis Patients at Prof. Dr. I.G.N.G. Ngoerah General Hospital, 2021–2024

Variable	N = 26
Age (years)	
0-<5	4
5-<10	3
10-18	19
Gender	
Male	12
Female	14
Type of TB	
Pulmonary TB	19
Extrapulmonary TB	7
Type of Extrapulmonary TB	
Miliary TB	1
Lymphadenitis TB	1
Pleural TB	1
Meningitis TB	1
Abdominal TB	1
Coxyitis TB	1
Skin TB	1
TB Contact History	
Yes	12
Denied	7
Unknown	7
BCG Vaccination History	
Yes	13
No	2
Unknown	11
Clinical Manifestation	
Fever ≥ 2 weeks	18
Cough ≥ 2 weeks	18

Weight loss/difficulty gaining weight	17
Dyspnea	15
Malaise	10
Lymphadenopathy	5
Swelling of bones/ joints	4
Night sweats	2
Nausea/ vomiting	2
Others	9
GeneXpert Result	
Positive	18
Negative	8
Acid Fast Bacilli (AFB) Smear Result	
Positive	4
Negative	1
Not examined	21
Tuberculin Skin Test (TST) Result	
Positive	8
Negative	1
Not examined	17
Chest X-Ray Result	
Suggestive findings of TB	19
No suggestive findings of TB	4
Not examined	3
Other Supporting Tests	
Yes	8
No	18
TB Case Status	
New	21
Relapse	2
Moving in	1
Discontinuation of medication	2
Comorbidities	
Yes	17
No	9
Types of Comorbidities	
Anemia	10
Pneumonia	7
Stunting	5
HIV	2
Heart disease	2
Systemic Lupus Erythematosus (SLE)	2
Renal disease	2
Diarrhea	1
Pneumothorax	1
Subclinical hypothyroid	1
Stevens-Johnson Syndrome (SJS)	1
Psychiatric disorder	1

Based on the demographic characteristics of pediatric TB patients at Prof. Dr. I.G.N.G. Ngoerah General Hospital from 2021 to 2024, as presented in Table 1, the mean age of patients was 11.8 ± 5.2 years with a median age of 14 years. There were slightly more female patients than male patients, with 14 female children and 12 male children. The study found that the majority of patients (19 children) were diagnosed with pulmonary TB, while 7 children had extrapulmonary TB. Additionally, most patients (17 children) had comorbidities, whereas 9 children had no comorbidities.

Based on the analysis, the mean body weight of children at the start of treatment was 28.75 ± 11.94 kg, which increased to 32.42 ± 13.55 kg after the intensive phase and 36.54 ± 14.28 kg after the continuation phase. Furthermore, the mean weight gain from the start of treatment to the end of the intensive phase was 3.67 ± 3.19 kg, followed by an increase of 4.12 ± 3.58 kg from the end of the intensive phase to the end of the continuation phase, resulting in a total weight gain of 7.79 ± 4.20 kg.

Table 2. Statistical Comparison of Mean Body Weight Increase Across Treatment Phases in Pediatric TB Patients

Comparison	n	Mean Increase (kg) ± SD	*p-value* (Bonferroni)	95% CI
Start to Intensive Phase	26	3,67 ± 3,19	<0,001	2.06-5.27
Intensive Phase to Continuation Phase	26	4,12 ± 3,58	<0,001	2.31-5.922
Start to Continuation Phase	26	7,79 ± 4,20	<0,001	5.67-9.90

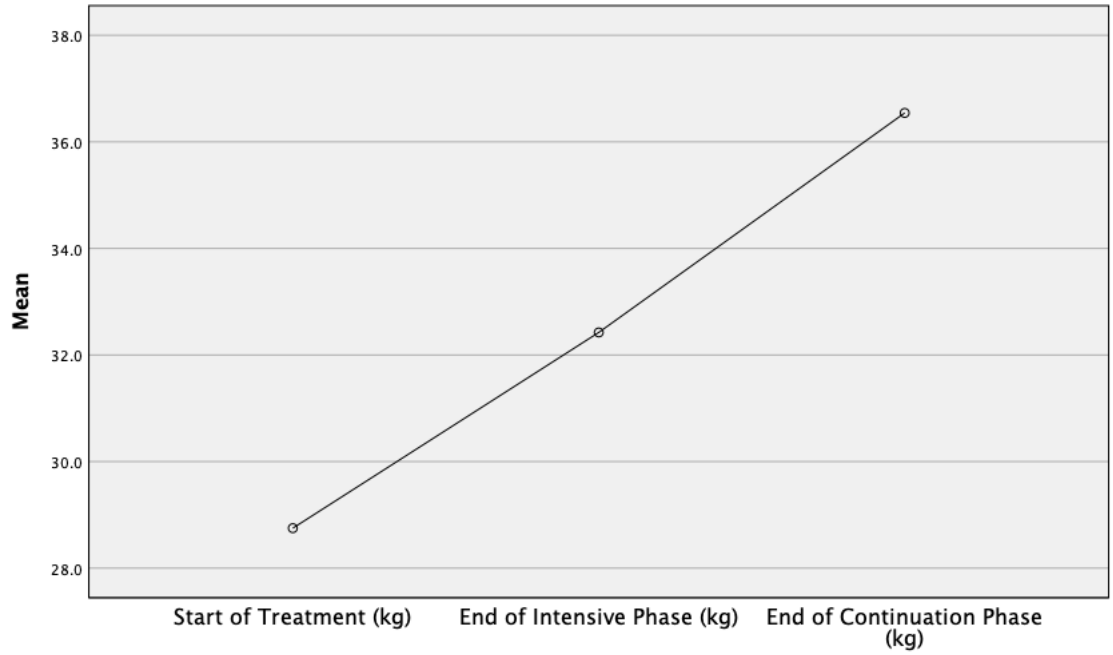

Figure 1. Trend of Mean Body Weight Changes in Pediatric TB Patients During ATD Therapy

Weight gain during ATD therapy occurred gradually and was statistically significant. When analyzed further based on the monthly rate of weight gain, the highest increase occurred during the intensive phase, with a rate of approximately 1.84 kg per month. During the continuation phase, the rate of weight gain slowed to approximately 1.03 kg per month. Overall, from the start of treatment to the end of the intensive phase, the average weight of children increased at a rate of 1.30 kg per month.

Table 3. Nutritional Status Distribution Based on ATD Treatment Stages

Nutritional Status	Start of Treatment	End of Intensive Phase	End of Continuation Phase
Overweight	0/26	0/26	1/26
Possible risk of overweight	0/26	0/26	2/26
Normal	8/26	14/26	17/26
Thinnes	4/26	7/26	4/26
Severe thinness	14/26	5/26	2/26

The nutritional status of children with TB in this study was assessed using BMI for Age (z-score) classification for all subjects aged 0–18 years. Based on Table 3, at the start of treatment, most children were classified as severely thin (14 children), 4 children were classified as thin, and 8 children had normal nutritional status. In addition to this categorical distribution, the mean BMI-for-age z-scores of 26 pediatric TB patients showed consistent improvements across three treatment stages, reflecting an overall improvement in nutritional status by the end of treatment.

Table 4. Mean Body Weight of Pediatric TB Patients Based on Age Group, Comorbidity Status, and Diagnostic Confirmation

Classification	n	Start of Treatment (kg) ± SD	End of Intensive Phase (kg) ± SD	End of Continuation Phase (kg) ± SD	Total Weight Gain (kg) ± SD
Age (years)					
0-<5	4	9,20 ± 2,45 kg	10,62 ± 2,62 kg	12,27 ± 1,15 kg	3,07 ± 1,50 kg
5-<10	3	20,33 ± 4.50 kg	25,16 ± 6,60 kg	28,33 ± 7,23 kg	8,00 ± 4,58 kg
10-18	19	34,19 ± 8,18 kg	38,15 ± 10,00 kg	42,94 ± 9,60 kg	8,75 ± 3,99 kg
Comorbidities					
Yes	17	27,64 ± 11,86 kg	31,52 ± 13,76 kg	36,03 ± 14,08 kg	8,38 ± 4,39 kg
No	9	30,83 ± 12,53 kg	34,12 ± 13,79 kg	37,50 ± 15,48 kg	6,66 ± 3,81 kg
Diagnostic Confirmation					
Bacteriologically Confirmed TB	21	30,19 ± 11,68 kg	33,73 ± 13,28 kg	38,14 ± 13,51 kg	7,95 ± 4,13 kg
Clinically Diagnosed TB	5	22,70 ± 12,36 kg	26,90 ± 14,81 kg	29,80 ± 17,09 kg	7,10 ± 4,92 kg

Based on table 4, children with TB showed an overall increase in mean body weight during ATD therapy across all groups. The lowest gain was in the 0-<5 years group (3.07 ± 1.50 kg), while older children gained more weight (8,00 ± 4,58 kg and 8,75 ± 3,99 kg). A significant difference in total weight gain was found across different age groups ($p = 0.024$). Although children with comorbidities and bacteriologically confirmed TB showed slightly higher weight gains than children without comorbidities and those clinically diagnosed with TB, the differences were not statistically significant ($p = 0.387$ and $p = 0.696$, respectively)

DISCUSSION

The characteristics of the study subjects show a dominant age distribution in the 10-18 years group (adolescents). The results of this study are different from those of Sari and Prabowo (2023), who found that most cases of childhood TB were in the 1-5 years group (52%), likely due to immature immune system and intense household contact, making children under 5 years old more susceptible to TB. However, the age distribution in this study aligns with previous studies reporting a high proportion of TB cases among adolescents, such as Shodikin et al. (2021) in Jember, where the highest number occurred in the 15–18 years group (33.3%), followed by 10–14 years (29.2%). Adolescents (10-18 years old) are at a higher risk of TB exposure compared to younger children or the elderly. This is due to their increased mobility and social contact outside the home, including exposure at school, public transportation, and within the community.

In contrast, TB transmission in children under 5 years typically occurs within the household (Laycock et al., 2021). This study identified more TB cases among adolescents than younger children is influenced by selection bias, as the research was conducted at a tertiary referral hospital that primarily receives complex and severe cases that are missed in primary care, and this explains why adolescent with more advanced or complicated TB were over-represented, whereas younger children with uncomplicated TB were generally treated in primary care. The gender distribution of this study shows a slightly higher proportion of female patients compared to male patients. This finding differs from Azzahra et al. (2024), who reported that pediatric TB cases were predominantly found in males (55.8%) compared to females (44.2%), likely because boys tend to be more active outdoors, thereby increasing their chances of being exposed to MTB from individuals with active TB. However, the results of this study are similar to Pratiwi et al. (2025), who also found that the proportion of female pediatric TB patients was slightly higher (50.5%) than male patients (49.5%). A meta-analysis by Siddalingaiah et al. (2023) concluded that there was no significant difference in TB risk between male and female children. Gender becomes a relevant risk factor after puberty due to differences in the role of hormones in modulating the immune response to infection.

Based on the results of this study, the number of pulmonary TB cases was higher than that of extrapulmonary TB cases. This result is consistent with previous studies reporting that the most common type of TB found in children is pulmonary TB. For example, a study by Soekotjo et al. (2019) reported that 61.5% of children had pulmonary TB, while 38.46% had extrapulmonary TB. The lungs are the primary organ first exposed to MTB via inhalation of infectious droplets, allowing the initial infection to develop as pulmonary TB. Meanwhile, extrapulmonary TB typically results from lymphohematogenous spread from pulmonary TB; reactivation of latent TB, particularly in immunocompromised children; or due to delayed diagnosis (Aygün et al., 2020; Baykan et al., 2022). Nearly half of the pediatric TB patients in this study had a history of contact with adult TB patients. These findings align with previous studies, such as Tenribali et al. (2024), who reported that 66% of children had a history of contact with adult TB patients. The researchers found a significant association between TB contact history and the occurrence of TB in children ($p<0.001$). Close and prolonged contact (>8 hours) with adults who have active TB significantly increases the risk of *Mycobacterium tuberculosis* (MTB) transmission to children. Such intense exposure creates conditions that facilitate the transmission, activation, and multiplication of MTB within a child's body (Agustin and Sulistyorini, 2023).

Most children in this study had a history of Bacillus Calmette-Guérun (BCG) vaccination. This finding is consistent with previous studies, such as Oktaviani et al. (2022), which reported that the majority of pediatric TB patients had a history of BCG vaccination (86.2%). However, TB infection can still occur despite vaccination, as BCG efficacy varies due to several factors, including vaccine strain, age at vaccination, exposure level, and host immunity. While BCG does not offer complete protection against TB infection, it significantly reduces the risk of severe TB forms such as meningitis TB and milliary TB, and lowers TB-related mortality across age groups (Liao et al., 2021; Martinez et al., 2022). In this study, pediatric TB patients exhibited a wide range of clinical symptoms, with each patient presenting 1 to 8 manifestations. The most frequently observed symptoms were fever lasting ≥ 2 weeks, cough lasting ≥ 2 weeks, weight loss, and dyspnea. These findings are consistent with existing literature. A study by Mohavedi et al. (2022) reported that the most common clinical manifestations in pediatric TB cases were weight loss (83%), fever lasting ≥ 2 weeks (80%), cough lasting ≥ 2 weeks (54%), and dyspnea (41%). Similarly, Dubois et al. (2022) also reported fever lasting ≥ 2 weeks (86%), weight loss (76.4%), and cough lasting ≥ 3 weeks (51.7%) as the predominant symptoms.

In this study, 21 children were diagnosed with TB through bacteriological confirmation, while 5 children were diagnosed based on clinical criteria. Based on the GeneXpert result, the

majority of children in this study tested positive (18 out of 26). This number is notably higher compared to previous studies, such as the study by Prasanti et al. (2025) in Surabaya, which reported more negative results than positive results. According to Agustina et al. (2019), the lower positivity rates in previous studies are likely due to the paucibacillary nature of MTB in children and difficulties in obtaining adequate sputum specimens, as children often swallow their sputum rather than expectorate it. The Acid-Fast Bacilli (AFB) smears in this study were performed on 5 out of 26 children. Despite the small sample size, 4 out of 5 yielded positive results, indicating that AFB smear was used selectively, mainly for diagnostic confirmation in specific cases. This differs from a study by Soekotjo et al. (2019), who reported that the majority of AFB smears in children were negative. The selective use of AFB smear in our study is likely because most patients had already undergone the GeneXpert test. As a result, AFB smears were primarily performed on children with negative GeneXpert results or in cases of severe clinical symptoms, unlike other studies that conducted AFB smears on a broader clinical population.

The Tuberculin Skin Test (TST) in this study was only performed on a limited number of children, but showed a high rate of positive results (8 out of 9). TST was selectively administered in children with negative GeneXpert or AFB results, unknown or denied contact history, and strong clinical indications of TB. The high proportion of positive TST among children tested is consistent with a study by Mohavedi et al. (2023), which reported a TST positivity rate of 92% among 89 children tested. A positive result on TST indicates the presence of MTB infection, but it does not confirm active TB disease. This test has a sensitivity and specificity of up to 90%. However, TST is not recommended as a screening modality due to its inability to differentiate between latent and active TB (Kemenkes, 2023). Chest X-rays were performed on most children in this study, and the majority revealed findings suggestive of active TB. These results align with previous research, a study by Mohavedi et al. (2023) found that 53.5% of pediatric TB patients had radiographic features suggestive of TB. Similarly, Singh et al. (2021) also reported that all pediatric patients with pulmonary TB (100%) showed suggestive radiological findings, whereas such features were observed in only 12% of children with extrapulmonary TB. The sensitivity and specificity of chest X-rays in children under 15 years with a history of TB exposure are 84% and 91%, respectively, highlighting their significant role in the TB diagnostic scoring system for children in Indonesia (Kemenkes, 2023).

The majority of pediatric patients in this study were classified as new cases, indicating that most children received a diagnosis and treatment for TB for the first time. This finding is consistent with the study by Kibirige et al. (2021), which reported that a higher proportion of new cases (81.74%), while 18.3% were classified as relapsed/retreatment cases (14.4%). The high incidence of new TB cases across studies is indicative that active transmission is still ongoing in the community, requiring greater efforts in prevention and early detection to break the chain of TB transmission (Sazali et al., 2022). The high proportion of pediatric TB patients with comorbidities in this study suggests that TB infection often coexists with other health conditions that can worsen the clinical condition of affected children. This finding aligns with Amelia and Kaswandani (2024) research at Dr. Cipto Mangunkusumo National General Hospital, which reported that the majority of pediatric TB patients also had comorbidities (53.6%). The most common comorbidities found in this study were anemia and pneumonia, whereas Amelia and Kaswandani (2024) reported HIV, malignancy, and heart disease as the most common comorbidities. These differences may reflect population characteristics and the scope of the study sample.

Changes in body weight during TB therapy are an important clinical indicator in evaluating treatment success in children. In this study, all children experienced weight gain after completing ATD therapy. This finding is consistent with a study by Bansal et al. (2023)

involving 117 pediatric TB patients in India, which reported that all children showed weight gain by the end of the continuation phase after completing ATD therapy. A similar study by Mexitalia et al. (2017) involving 40 pediatric TB patients in Central Java also revealed significant weight gain in all children after ATD therapy ($p<0.001$). The increase in body weight in this study was consistent and significant until the end of treatment. Statistical analysis using Repeated Measures ANOVA ($p<0.001$) and Post Hoc tests ($p<0.001$) confirmed a significant difference in mean weight across all three measurement points (start of treatment, end of the intensive phase, end of the continuation phase). This indicates that each phase of ATD therapy contributed to weight gain in children. Specifically, the most substantial weight gain occurred during the intensive phase, with an average rate of 1.84 kg per month. The rate of weight gain then slowed to approximately 1.03 kg per month during the continuation phase.

Weight gain in children during ATD therapy is strongly associated with leptin hormone regulation. During TB treatment, there is a reduction in acute phase response and production of proinflammatory cytokines (TNF-α and C-reactive protein), accompanied by an increase in leptin concentration. A more significant increase in leptin concentration occurs during the intensive phase, consistent with the reduction in bacterial load and acute phase response during this period. The increase in leptin concentration in pediatric TB patients plays a crucial role in stimulating appetite, leading to greater intake of essential nutrients (carbohydrates, proteins, and fats), which directly promotes weight gain. In contrast, untreated TB patients experience a decrease in body fat mass, reduced nutrient intake, and worsening of the immune response, which directly impacts the decrease in leptin concentration and, consequently, leads to poorer clinical outcomes (Mexitalia et al., 2017). In addition to weight gain, nutritional status also improved during ATD therapy. At the start of treatment, most children in this study were classified as severely thin (z-score $<$ -3 SD) based on BMI-for-age. This finding aligns with the results of Azzahra et al. (2024), which reported a high proportion of children with severe malnutrition at the start of treatment.

This study found that nutritional status significantly improved, particularly after the intensive phase of ATD therapy, as marked by a significant increase in mean BMI-for-age z-scores across all treatment stages (Repeated Measures ANOVA, $p<0.001$; Post Hoc, $p<0.001$). The mean z-score shifted from the severe thinness range at the treatment initiation to the normal range by the end of therapy. These findings are consistent with Amelia and Kaswandani (2024), who also reported a decrease in the proportion of children with severe malnutrition and an increase in the proportion of children in normal nutritional status after ATD therapy. Despite overall improvements, 2 of 26 children in this study remained in the severe thinness category after completing treatment. Although both gained absolute weight, the improvement was insufficient to reach a normal BMI-for-age. These cases involved complex comorbidities such as marasmus, pneumothorax, nosocomial pneumonia, severe anemia, and diarrhea, which may limit nutritional recovery. However, when evaluated using the Waterlow classification (weight-for-height), both children showed improvement from severe malnutrition to moderate malnutrition, suggesting that BMI-for-age alone may not fully capture subtle improvements in nutritional status.

Weight gain in pediatric TB patients appeared to be influenced by several factors. The analysis showed that age had a significant effect on weight gain, with the 10-18 years group experiencing the greatest increase. Aligns with physiological growth, younger children ($<$ 1 years) have faster relative growth rates (kg per kg of body weight), whereas older children tend to gain more absolute weight (kg per year) due primarily to greater baseline body mass. This physiological principle was reflected in the regression analysis, which demonstrated a positive association between age and weight gain ($B = 0.443$). Nevertheless, differences in mean weight gain based on comorbidity status and diagnostic confirmation were not statistically significant.

These findings suggest that these variables do not act independently, but rather interact with each other, with age emerging as the dominant variable.

The cross-tabulation revealed a dominant distribution in the 10-18 years group, particularly among children with bacteriologically confirmed TB and comorbidities (n=11), followed by those without comorbidities in the same age group (n=6). In contrast, the 0-<5 and 5-<10 years groups were underrepresented, with only 1-2 children in each diagnostic and comorbidities combination. This uneven and overlapping distribution across age, diagnostic method, and comorbidity status limits the ability to interpret the effect of each variable independently without accounting for their interactions. The strong influence of age may have acted as a confounding variable, making it difficult to isolate the effects of comorbidity status and diagnostic category on weight gain in the regression model. Overall, weight gain during ATD therapy in children appears to reflect a complex interaction between age, comorbidity status, and diagnostic confirmation, rather than the independent contribution of each variable. This study has several limitations. This study employed a retrospective design and utilized anthropometric data from medical records, which raises the possibility of measurement bias. However, all measurements were taken at the same pediatric clinic, which helped maintain data consistency. Additionally, the relatively small sample size limits the ability to generalize these findings to the broader population. Further research with larger sample sizes and prospective designs is needed to improve analytical precision and clarify the individual roles of age, comorbidities, and diagnostic methods in determining weight gain during TB therapy in the pediatric population.

CONCLUSION

In conclusion, this study found that the majority of pediatric TB patients were 10-18 years (adolescents), with a slightly higher proportion of females. Pulmonary TB was the predominant type and had bacteriological confirmation as new cases. The most frequently reported clinical manifestations included prolonged fever, persistent cough, and weight loss. Anemia and pneumonia were the most common comorbidities observed. A significant increase in body weight was observed during ATD therapy (Repeated Measures ANOVA, $p < 0.001$). The mean body weight increased from 28.75 ± 11.94 kg at treatment initiation to 36.54 ± 14.28 kg by the end of therapy, with the most rapid gain occurring during the intensive phase (1.84kg/month). Nutritional status also improved significantly, as reflected by a shift in mean BMI-for-age z-scores from severe thin range to normal, and the number of children classified as severely thin decreased from 14 to 2, while those with normal nutritional status increased from 8 to 17 by the end of treatment.

ACKNOWLEDGEMENT

The authors express their sincere gratitude to the Faculty of Medicine, Udayana University, and Prof. Dr. I.G.N.G. Ngoerah General Hospital for their support and for providing access to the patient data required for this research.

REFERENCES

Agustin, A. F. A., & Sulistyorini, L. 2023. *Association of Contact History and Family Behavior with Tuberculosis in Children at Banyu Urip Public Health Center, Surabaya City, Indonesia: A Case-Control Study. Public Health and Preventive Medicine Archive*, *11*(2), 211–221. https://doi.org/10.53638/phpma.2023.v11.i2.p09

Agustina, B., Kartasasmita, C., & Hilmanto, D. 2019. *Comparison of GeneXpert MTB to Mycobacterium tuberculosis culture in children with tuberculosis. Paediatrica Indonesiana(Paediatrica Indonesiana)*, *59*(3), 113–118. https://doi.org/10.14238/pi59.3.2019.113-8

Amelia, S., & Kaswandani, N. 2024. *Correlation Between Tuberculosis Type and Comorbidities with Nutritional Recovery Rates Post-Tuberculosis Treatment in Pediatric Patients. Archives of Pediatric Gastroenterology, Hepatology, and Nutrition*, *3*, 1. https://doi.org/https://doi.org/10.58427/apghn.3.3.2024.1-11

Aygün, D., Yıldırım, T., Öner, Ö. B., & Şiraneci, R. 2020. *Evaluation of Clinical and Laboratory Characteristics of Childhood Tuberculosis. Turkish Archives of Pediatrics*, *55*(3), 236–243. https://doi.org/10.14744/TurkPediatriArs.2020.02438

Azzahra, F., Sofiah, F., Lestari, H. I., Alia, R. A. M., & Ayu, D. R. 2024. *Comparison of Characteristics of Outpatient and Inpatient Child Pulmonary Tuberculosis Patients at Dr. Mohammad Hoesin Hospital* Palembang. *Jurnal RSMH Palembang*, *5*(2), 377–387.

Bansal, P., Mishra, S., & Ambey, R. 2023. *Weight Gain Pattern in Children Below 14 Years Undergoing Antitubercular Therapy. International Journal of Toxicological and Pharmacological Research*, 100–105. https://impactfactor.org/PDF/IJTPR/13/IJTPR,Vol13,Issue5,Article14.pdf

Baykan, A. H., Sayiner, H. S., Aydin, E., Koc, M., Inan, I., & Erturk, S. M. 2022. *Extrapulmonary Tuberculosıs: An Old but Resurgent Problem. Dalam Insights into Imaging (Vol. 13, Nomor 1). Springer Science and Business Media Deutschland GmbH*. https://doi.org/10.1186/s13244-022-01172-0

Centers for Disease Control and Prevention. 2024. *Tuberculosis in Children*. [online] Tuberculosis (TB). Available at: https://www.cdc.gov/tb/about/children.html [Accessed 28 Mar. 2024].

Dubois, M. M., Brooks, M. B., Malik, A. A., Siddiqui, S., Ahmed, J. F., Jaswal, M., Amanullah, F., Becerra, M. C., & Hussain, H. 2022. *Age-specific Clinical Presentation and Risk Factors for Extrapulmonary Tuberculosis Disease in Children*. *Pediatric Infectious Disease Journal*, *41*(8), 620–625. https://doi.org/10.1097/INF.0000000000003584

Kementerian Kesehatan Republik Indonesia. 2023. Petunjuk Teknis Tata Laksana Tuberkulosis Anak dan Remaja. [online] Jakarta: Kementerian Kesehatan RI, pp.978–623301–4274. Available at: https://www.tbindonesia.or.id/wp-content/uploads/2024/02/Final-Petunjuk-Teknis-Tata-Laksana-TBC-Anak-dan-Remaja-2023.pdf [Accessed 10 May 2025].

Kementerian Kesehatan Republik Indonesia. 2024. Dashboard Data Kondisi TBC di Indonesia. [online]. Available at: https://tbindonesia.or.id/pustaka-tbc/dashboard/ [Accessed 3 May 2024].

Kibirige, L., Izudi, J., & Okoboi, S. 2021. *Discontinuation of Tuberculosis Treatment Among Children in The Kampala Capital City Authority Health Facilities: A Mixed-methods Study*. *BMC Infectious Diseases*, *21*(1). https://doi.org/10.1186/s12879-021-06244-y

Kumar, G. S., Sameena, P., Karthik, V., & Ghanate, N. 2023. *Prospective Study on Outcome of MDR-TB Using the Shorter Regimen During COVID-19 Pandemic*. *Journal of Family Medicine and Primary Care*, *12*(6), 1087–1091. https://doi.org/10.4103/jfmpc.jfmpc_1723_22

Laycock, K. M., Enane, L. A., & Steenhoff, A. P. 2021. *Tuberculosis in Adolescents and Young Adults: Emerging Data on TB Transmission and Prevention Among Vulnerable Young People*. Dalam *Tropical Medicine and Infectious Disease* (Vol. 6, Nomor 3). MDPI. https://doi.org/10.3390/TROPICALMED6030148

Liao, Q., Zheng, Y., Wang, Y., Ye, L., Liu, X., Jiao, W., Liu, Y., Zhu, Y., Jia, J., Sun, L., Shen, A., & Wan, C. 2022. *Effectiveness of Bacillus Calmette-Guérin vaccination against*

severe childhood tuberculosis in China: a case-based, multicenter retrospective study. *International Journal of Infectious Diseases*, *121*, 113–119. https://doi.org/10.1016/j.ijid.2022.04.023

Martinez, L., Cords, O., Liu, Q., Acuna-Villaorduna, C., Bonnet, M., Fox, G. J., Carvalho, A. C. C., Chan, P. C., Croda, J., Hill, P. C., Lopez-Varela, E., Donkor, S., Fielding, K., Graham, S. M., Espinal, M. A., Kampmann, B., Reingold, A., Huerga, H., Villalba, J. A., … Andrews, J. R. 2022. *Infant BCG Vaccination and Risk of Pulmonary and Extrapulmonary Tuberculosis Throughout the Life Course: A Systematic Review and Individual Participant Data Meta-Analysis. The Lancet Global Health*, *10*(9), e1307–e1316. https://doi.org/10.1016/S2214-109X(22)00283-2

Mexitalia, M., Dewi, Y. O., Pramono, A., & Anam, M. S. 2017. *Effect of Tuberculosis Treatment on Leptin Levels, Weight Gain, and Percentage Body Fat in Indonesian Children. Korean Journal of Pediatrics*, *60*(4), 118. https://doi.org/10.3345/kjp.2017.60.4.118

Padmapriyadarsini, C., Shobana, M., Lakshmi, M., Beena, T., & Swaminathan, S. 2016. *Undernutrition & Tuberculosis in India: Situation Analysis & The Way Forward*. *Indian Journal of Medical Research*, *144*(1), 11. https://doi.org/10.4103/0971-5916.193278

Pratiwi, W., Toipah, I., Rachmawan, Y. P., & Reki, W. 2025. *The Features of Children with Tuberculosis at Sidawangi Pulmonary Hospital in Indonesia: Interactions within the Home as a Potential Transmission Risk*. *GHMJ (Global Health Management Journal)*, *8*(1), 55–61. https://doi.org/10.35898/ghmj-811203

Sari, R. O., & Prabowo, B. 2023. *Characteristics of Pediatric Tuberculosis Patients at Simpang Lima Gumul Hospital, Kediri, East Java*. *Asian Journal of Health Research*, *2*(2), 10–15. https://doi.org/10.55561/ajhr.v2i2.110

Sazali, M. F., Rahim, S. S. S. A., Mohammad, A. H., Kadir, F., Payus, A. O., Avoi, R., Jeffree, M. S., Omar, A., Ibrahim, M. Y., Atil, A., Tuah, N. M., Dapari, R., Lansing, M. G., Rahim, A. A. A., & Azhar, Z. I. 2023. *Improving Tuberculosis Medication Adherence: The Potential of Integrating Digital Technology and Health Belief Model*. Dalam *Tuberculosis and Respiratory Diseases* (Vol. 86, Nomor 2, hlm. 82–93). Korean National Tuberculosis Association. https://doi.org/10.4046/trd.2022.0148

Setyoningrum, R. A., Maharani, R. A., Hapsari, R., & Chafid, A. P. P. 2024. *Risk Factors of Tuberculosis in Children with Adult Household Tuberculosis Contact*. *Paediatrica Indonesiana(Paediatrica Indonesiana)*, *64*(4), 287–292. https://doi.org/10.14238/pi64.4.2024.287-92

Shodikin, M. A., Nastiti Ayu, P. P., & Handoko, A. 2021. Hubungan Riwayat Tuberkulosis Paru pada Keluarga dengan Terjadinya Limfadenitis Tuberkulosis pada Anak. *Jurnal Kesehatan Masyarakat Indonesia*, *16*(3), 168. https://doi.org/10.26714/jkmi.16.3.2021.168-176

Siddalingaiah, N., Chawla, K., Nagaraja, S. B., & Hazra, D. 2023. *Risk Factors for The Development of Tuberculosis Among The Pediatric Population: A Systematic Review and Meta-analysis*. Dalam *European Journal of Pediatrics* (Vol. 182, Nomor 7, hlm. 3007–3019). *Springer Science and Business Media Deutschland GmbH*. https://doi.org/10.1007/s00431-023-04988-0

Singh, S., Chegondi, M., Chacham, S., Kumar, P., & Goyal, J. P. 2021. *Comparison of Clinical and Laboratory Profile of Pulmonary and Extrapulmonary Tuberculosis in Children: A Single-Center Experience from India. Journal of Clinical and Translational Research*, *7*(4), 423–427. https://doi.org/10.18053/jctres.07.202104.004

Soekotjo, F. N., Sudarwati, S., & Alam, A. 2019. *Clinical Profile of TB in Children at Pediatric Outpatient Clinic Hasan Sadikin Hospital Bandung 2016*. *Journal of Medicine & Health*, *2*(3). https://doi.org/10.28932/jmh.v2i3.1221

Tenribali, A. W. Y., Jafar, M. A., Ratnawati, W., Darussalam, A. H. E., & Nikmawati. 2024. *Characteristics Of Childhood Tuberculosis Patients At La Palaloi Maros Regional Hospital-Andi We Yada Tenribali et.al Characteristics Of Childhood Tuberculosis Patients At La Palaloi Maros Regional Hospital*. *Jurnal EduHealth*, *15*, 2024. https://doi.org/10.54209/eduhealth.v15i02

World Health Organization. 2022. *Global Tuberculosis Report 2022*. [online]. *Available at*: https://www.who.int/publications/i/item/9789240061729 [Accessed 16 Sep. 2023].

World Health Organization. 2024. *Tuberculosis*. [online] *Available at*: https://www.who.int/health-topics/tuberculosis#tab=tab_1 [Accessed 3 Jan. 2024].