Jurnal Epidemiologi Kesehatan Komunitas
11 (2), 2026, 165-174

JEKK


# Environmental Conditions, Laboratory Profiles, and Vitamin D Status among Children Living with HIV and TB–HIV in Semarang, Indonesia

Lintang Dian Saraswati[1*], Bagoes Widjanarko[2], Ari Probandari[3], Jerico Pardosi[4]

[1]Department of Epidemiology, Public Health Faculty, Universitas Diponegoro, Semarang, Indonesia
[2]Health Promotion Department of Public Health Faculty, Universitas Diponegoro, Semarang, Indonesia
[3]Department of Public Health, Faculty of Medicine, Sebelas Maret University University, Solo, Indonesia
[4]School of Public Health and Social Work, Faculty of Public Health, Queensland University of Technology, Brisbane, Australia

*Article Information : Received 30 May 2026 ; Last Revised 06 June 2026 ; Accepted 08 June 2026 ; Available Online 08 June 2026 ; Published 08 June 2026*

## ABSTRACT

**Background:** Evidence regarding environmental conditions, laboratory profiles, and micronutrient status among Indonesian children living with HIV and TB–HIV co-infection remains limited. This study aimed to describe household environmental conditions, laboratory profiles, and vitamin status among children living with HIV and TB–HIV in Semarang, Indonesia.
**Methods:** A descriptive cross-sectional study was conducted at the Pulmonary Health Center of Semarang, Indonesia, between June and October 2017. Total sampling was used to recruit all eligible children with HIV or TB–HIV co-infection (n=13). Descriptive analyses were performed to summarize environmental conditions, laboratory findings, and vitamin status.
**Results:** More than half of the participants lived in houses with light intensity below 60 lx, and two lived in houses with soil floors. Most households had at least one active smoker, and most participants had a history of household contact with active TB cases. Haematological and immunological findings were generally within normal limits, although one participant had anemia and another demonstrated marked immunosuppression. Vitamin D insufficiency was the most common micronutrient abnormality. Vitamin A deficiency was identified in two participants, while elevated vitamin E levels were observed in six participants.
**Conclusion:** Inadequate household lighting, exposure to cigarette smoke, and micronutrient abnormalities, particularly vitamin D insufficiency, were common among children living with HIV and TB–HIV in this study. These findings provide descriptive information that may support future research and clinical assessment in this population.

**Keywords:** children living with HIV; TB-HIV co-infection; Micronutrients ; Vitamin D Insufficiency ; Household Environmental Conditions


DOI : https://doi.org/10.14710/jekk.v11i2.32519

*Corresponding author, lintang.saraswati@live.undip.ac.id

## Introduction

Tuberculosis (TB) remains one of the most important opportunistic infections and the leading cause of death among people living with HIV (PLHIV). HIV infection substantially increases the risk of developing active TB due to progressive impairment of cellular immunity. The World Health Organization (WHO) estimates that PLHIV are approximately 18 times more likely to develop active TB than HIV-negative individuals. In turn, TB accelerates HIV disease progression, increases morbidity, and contributes substantially to mortality among PLHIV.[1,2]

Despite significant advances in HIV prevention and treatment, HIV infection among children remains a major public health challenge, particularly in low- and middle-income countries. According to UNAIDS, approximately 1.4 million children aged 0–14 years were living with HIV worldwide in 2024.[3] Most paediatric HIV infections occur through mother-to-child transmission during pregnancy, delivery, or breastfeeding. Children living with HIV are especially vulnerable to infectious diseases because of their immature immune systems and HIV-related immunosuppression. Consequently, the burden of TB–HIV co-infection among children remains substantial in many high-burden settings.[4]

The interaction between TB and HIV in children presents unique clinical and public health challenges. HIV-induced immune suppression increases the risk of progression from latent TB infection to active disease and complicates TB diagnosis and treatment.[2] In addition to biological factors, environmental conditions may also contribute to the occurrence and progression of TB among HIV-infected children. Household crowding, inadequate ventilation, poor lighting, and exposure to second-hand cigarette smoke have been associated with increased TB transmission and poorer respiratory health outcomes.[5–8] Children are particularly vulnerable to environmental exposures because they spend a substantial proportion of their time inside the household environment.

Nutritional status is another important determinant of immune function and disease progression among children with HIV infection. Micronutrients, including vitamins A, D, and E, play essential roles in maintaining immune responses, reducing oxidative stress, and supporting resistance against infectious diseases. Vitamin D has received particular attention because of its role in macrophage activation and host defence against Mycobacterium tuberculosis. Previous studies have reported that vitamin D deficiency is common among PLHIV and has been associated with susceptibility to TB and poorer clinical outcomes.[11–14] However, evidence regarding micronutrient status among children with TB–HIV co-infection in Indonesia remains limited.

Although environmental exposures and micronutrient deficiencies have been widely studied among adults living with HIV, evidence among children with HIV and TB–HIV co-infection remains scarce, particularly in low- and middle-income countries. In Indonesia, published data describing household environmental conditions, haematological and immunological profiles, urinary findings, and micronutrient status among children affected by HIV and TB–HIV are limited. Furthermore, comprehensive assessments that combine environmental, laboratory, and nutritional evaluations in this population are rarely reported. Such information is important for understanding the health and living conditions of children affected by HIV and TB–HIV and for identifying areas that warrant further investigation.

Understanding environmental and nutritional conditions among children with HIV and TB–HIV co-infection is important because these factors may be associated with health status and wellbeing. The dataset analysed in this study provides a unique opportunity to describe household environmental conditions, haematological and immunological profiles, urinary findings, and vitamin status among children receiving HIV and TB care in Central Java, Indonesia. Given the limited evidence available from Indonesia, these findings may provide preliminary

information for future research and support the consideration of environmental assessment and nutritional monitoring within routine HIV and TB care. Therefore, this study aimed to describe household environmental factors, haematological and immunological profiles, urinary findings, and vitamin A, vitamin E, and vitamin D status among children with HIV and TB–HIV co-infection attending the Pulmonary Health Center of Semarang, Central Java, Indonesia.

## Methods

### A. Participants and Study Design

This study employed an observational cross-sectional design to provide a comprehensive description of environmental, nutritional, and laboratory characteristics among children with HIV infection and TB–HIV co-infection. Data collection was conducted from June to October 2017 at the Pulmonary Health Center of Semarang, Central Java, Indonesia, a referral facility providing HIV and TB services for children. Given the relatively small number of paediatric HIV and TB–HIV cases receiving care at the centre during the study period, total sampling was used to include all eligible participants and maximise the available information. Eligible participants were children diagnosed with HIV infection or TB–HIV co-infection who were receiving care at the Pulmonary Health Center of Semarang during the study period and whose parents or legal guardians provided informed consent for participation. A total of 13 children participated in the study, consisting of five children with HIV infection and eight children with TB–HIV co-infection. Although the findings may not be generalisable to all children living with HIV in Indonesia, the study provides important preliminary information from a population for which local evidence remains limited.

### B. Measurements and Procedure

The participants underwent clinical, environmental, nutritional, and laboratory assessments. Tuberculosis diagnosis was established through clinical examination, sputum examination, and chest radiography, while HIV infection was confirmed using the national HIV testing algorithm.

Household environmental factors were selected based on previous evidence suggesting their potential role in TB transmission and disease progression, particularly among immunocompromised individuals. Factors such as household crowding, ventilation, lighting, humidity, floor conditions, and exposure to cigarette smoke have been associated with increased risk of respiratory infections and tuberculosis in various settings. Therefore, these factors were assessed to identify potentially modifiable environmental conditions among children living with HIV and TB–HIV co-infection.

Household environmental assessments included population density, lighting intensity, humidity, ventilation, floor conditions, and exposure to cigarette smoke within the household. Lighting intensity was measured using a lux meter and classified according to the standards of the Indonesian Ministry of Health.

Anthropometric measurements included body weight, height, mid-upper arm circumference (MUAC), and body fat percentage. Body weight was measured using a digital scale, height was measured using a microtoise, and body fat percentage was assessed using a bioelectrical impedance analyzer (BIA). Nutritional status was evaluated using the WHO AnthroPlus software.

Laboratory examinations included routine haematological assessments, CD4 and CD8 lymphocyte counts, urine examination, and serum vitamin A, vitamin E, and vitamin D measurements. Routine haematological parameters included hemoglobin, hematocrit, erythrocyte, leukocyte, and platelet counts. Urine examinations were used to assess leukocyte esterase, nitrite, albumin, and glucose levels. Serum vitamin A, vitamin E, and 25-hydroxyvitamin D [25(OH)D] levels were measured to assess micronutrient status. Vitamin status was interpreted using the laboratory reference ranges applied at the time of examination. Vitamin A deficiency was defined as serum vitamin A levels below 200 µg/L, normal vitamin E levels ranged from 3–

14 mg/L, and vitamin D insufficiency was defined as serum 25-hydroxyvitamin D concentrations below 30 ng/mL.

### C. Statistical Analysis

The data were analyzed descriptively. Categorical variables are presented as frequencies and percentages, whereas continuous variables are presented as individual measurements, summary values, and laboratory profiles. The results were summarized using tables and narrative descriptions because the primary objective of the study was to characterise environmental conditions, laboratory findings, and micronutrient status among the participants.

### D. Ethical Clearance

Ethical approval was obtained from the Health Research Ethics Committee of the Faculty of Public Health, Diponegoro University (No. 114/EC/FKM/2017). Written informed consent was obtained from the parents or legal guardians of all participants before their enrolment in the study. The confidentiality and anonymity of the participants were maintained throughout the research process.

## Result

### A. Characteristics of Participants

A total of 13 children participated in this study, consisting of eight with TB–HIV co-infection and five with HIV infection. Most participants were male (n=7), while six were female. The majority of respondents were aged 5–10 years old. Most participants had a normal birth weight (≥2500 g), although birth weight information was unavailable for four respondents because their parents had died.

**Table 1. Household Environmental Conditions of Respondents**

| Environmental Factors | Total (f) | Percent (%) |
|---|---|---|
| Population Density – Not eligible | 5 | 38,5 |
| Population Density – Eligible | 8 | 61,5 |
| Lighting Levels – Not qualified | 8 | 61,5 |
| Lighting Levels – Qualified | 5 | 38,5 |
| Level of Humidity – Not qualified | 1 | 7,7 |
| Level of Humidity – Qualified | 12 | 92,3 |
| Presence of Ventilation – Not eligible | 4 | 30,8 |
| Presence of Ventilation – Eligible | 9 | 69,2 |
| Composition of the floor – A half or whole made of soil | 2 | 15,4 |
| Composition of the floor – Whole floor made of tile/plaster | 11 | 84,6 |

### E. Household Environmental Conditions

Table 1 presents the respondents' household environmental conditions. Most households met the recommended standards for population density (58.3%), humidity (91.7%), ventilation (66.7%), and floor condition (83.3%). However, inadequate lighting was observed in 58.3% of the households. Two respondents (16.7%) lived in houses with earthen floors.

### F. Exposure to Cigarette Smoke

Exposure to cigarette smoke within households was common among participants. Twelve of the thirteen respondents (92.3%) lived in households with at least one active smoker. Smoking most frequently occurred in family rooms (8 households, 66.7%), followed by living rooms (5 households, 41.7%). Because smoking could occur in more than one location within the same household, smoking location categories were not mutually exclusive.

**Table 2. Household Smoking Exposure**

| Variable | f | % |
|---|---|---|
| **Presence of smoker inside house** | | |
| Yes | 12 | 92,3 |
| No | 1 | 7,7 |

| Variable | f | % |
|---|---|---|
| **Smoking location** | | |
| Terrace | 0 | 0,0 |
| Living room | 5 | 41,7 |
| Family room | 8 | 66,7 |

*† Percentages for smoking location were calculated using only households with smokers (n = 12). Categories were not mutually exclusive; some households reported smoking in more than one location.*

### G. Haematological Profile

The routine haematological examination results are presented in Table 3. Most respondents demonstrated haematological parameters within the normal reference range. One respondent (VP) had hemoglobin levels below the normal range, indicating anemia. Several respondents had hematocrit values below the reference range. One participant had a reduced erythrocyte count, and another had a slightly decreased leukocyte count. The platelet counts were within the normal range for all respondents.

### H. Immunological Profile

The results of the CD4 and CD8 lymphocyte examinations are presented in Table 4. Most respondents had CD4 counts > 500 cells/µL. One respondent (BDO) had a CD4 count of 338 cells/µL and a CD4 percentage of 9.7%. CD8 counts varied among participants, with the highest value observed in respondent BDO (1,967 cells/µL). The CD4 ratio ranged from 0.17–1.37. Several respondents had CD4 ratios below 1.0.

### I. Urinary Findings

The results of routine urine examination are presented in Table 5. Most respondents had negative results for leukocyte esterase, nitrite, albumin, and glucose. One participant demonstrated elevated leukocyte esterase levels [500 (+3)], whereas another had mild albuminuria [25 (+1)]. None of the respondents had positive nitrite or glucose findings.

### J. Vitamin A, Vitamin E, and Vitamin D Status

The results of the vitamin examinations are presented in Table 6. Two respondents had vitamin A levels below the normal reference range. One respondent had elevated vitamin E levels. Vitamin D insufficiency was the most common micronutrient abnormality observed, with most participants having serum 25-hydroxyvitamin D concentrations below 30 ng/mL. Severe vitamin D deficiency was observed in several participants, including VP (10.2 ng/mL), INA (9.4 ng/mL), and MA (8.8 ng/mL).

**Table 3. Haematological Examination Results**

| ID code | Sex | Hb | Hematokrit | Eritrosit | Trombosit | Leukosit |
|---|---|---|---|---|---|---|
| VP | Male | 10.4 | 31.5 | 5.47 | 350 | 8.2 |
| BDO | Male | 12.8 | 37.7 | 4.60 | 526 | 14.3 |
| F | Female | 12.7 | 35.1 | 3.88 | 260 | 7.8 |
| INA | Female | 13.9 | 40.1 | 5.12 | 277 | 5.8 |
| MA | Male | 12.4 | 33.5 | 3.98 | 429 | 9.1 |
| FA | Male | 11.9 | 32.9 | 4.78 | 287 | 12.3 |
| V | Female | 13.2 | 34.1 | 4.23 | 389 | 11.4 |
| K | Female | 13.6 | 33.4 | 5.16 | 281 | 14.6 |
| C | Female | 12.6 | 35.5 | 4.71 | 460 | 12.2 |
| FI | Male | 12.2 | 36.7 | 4.38 | 362 | 13.7 |
| BM | Male | 11.7 | 40.6 | 5.18 | 438 | 6.9 |
| BF | Male | 13.9 | 37.3 | 3.29 | 321 | 7.7 |

**Table 4. CD4 and CD8 Lymphocyte Profiles**

| ID Code | Sex | Subtipe Limfosit (CD4&CD8) | | | | |
|---|---|---|---|---|---|---|
| | | CD4 Absolut | CD4 % | CD8 Absolut | Cd8 % | Rasio CD4 : CD8 |
| VP | Male | 846 | 32,0 | 617 | 23,3 | 1,37 |
| BDO | Male | 338 | 9,7 | 1,967 | 56,4 | 0,17 |
| F | Female | 1,252 | 32,6 | 1,325 | 34,5 | 0,94 |
| INA | Female | 648 | 32,0 | 715 | 35,3 | 0,91 |
| MA | Male | 892 | 32,9 | 727 | 34,2 | 1,23 |
| FA | Male | 1268 | 36,2 | 1175 | 40,8 | 1,08 |
| V | Female | 789 | 33,5 | 976 | 28,3 | 0,81 |
| K | Female | 645 | 32,1 | 825 | 32,1 | 0,78 |
| C | Female | 871 | 31,9 | 911 | 31,9 | 0,96 |
| FI | Male | 523 | 27,1 | 1219 | 37,3 | 0,43 |
| BM | Male | 812 | 30,1 | 987 | 29,8 | 0,82 |
| BF | Male | 946 | 35,7 | 1182 | 39,8 | 0,80 |

**Table 5. Urine Examination Results**

| ID code | Sex | Leukosit Esterase | Nitrit | Albumin | Glukosa |
|---|---|---|---|---|---|
| VP | Male | Negative | Negative | Negative | Negative |
| BDO | Male | Negative | Negative | Negative | Negative |
| F | Female | 500 (+3) | Negative | Negative | Negative |
| INA | Female | Negative | Negative | 25 (+1) | Negative |
| MA | Male | Negative | Negative | Negative | Negative |
| FA | Male | Negative | Negative | Negative | Negative |
| V | Female | Negative | Negative | Negative | Negative |
| K | Female | Negative | Negative | Negative | Negative |
| C | Female | Negative | Negative | Negative | Negative |
| FI | Male | Negative | Negative | Negative | Negative |
| BM | Male | Negative | Negative | Negative | Negative |
| BF | Male | Negative | Negative | Negative | Negative |

**Table 6. Vitamin A, Vitamin E, and Vitamin D Examination Results**

| ID code | Sex | Vitamin A | Vitamin E | Vitamin D 25-OH Total |
|---|---|---|---|---|
| VP | Male | 191 | 11 | 10.2 |
| BDO | Male | 211 | 11 | 22.8 |
| F | Female | 408 | 20 | 22.8 |
| INA | Female | 354 | 17 | 9.4 |
| MA | Male | 211 | 18 | 8.8 |
| FA | Male | 196 | 10 | 12.8 |
| V | Female | 214 | 14 | 11.9 |
| K | Female | 226 | 13 | 14.2 |
| C | Female | 345 | 19 | 13.9 |
| FI | Male | 281 | 15 | 15.7 |
| BM | Male | 422 | 12 | 18.2 |
| BF | Male | 310 | 16 | 19.1 |

## Discussion

### A. Environmental Conditions and Exposure to Cigarette Smoke

This study found that most household environmental conditions met the recommended standards, except for lighting conditions and exposure to cigarette smoke. More than half of the respondents lived in houses with inadequate lighting levels, and almost all respondents were exposed to active smokers within the household.. These findings are noteworthy because previous studies have reported associations between environmental conditions and TB transmission among vulnerable populations, including children living with HIV.

Previous studies have suggested that adequate sunlight exposure may reduce the survival of *Mycobacterium tuberculosis* in indoor environments. In addition, previous studies have demonstrated that reduced sunlight exposure and lower ultraviolet radiation are associated with increased TB incidences. MacLachlan et al. reported that geographical variations in sunlight exposure contributed to differences in TB seasonality, whereas Koh et al. observed that periods of lower sunshine exposure were followed by increased TB incidence.[7,8] Furthermore, sunlight exposure is closely related to vitamin D synthesis, which plays an important role in immune responses against TB.[11,12]

Exposure to cigarette smoke was highly prevalent among the participants. Most respondents lived with at least one active smoker, and smoking commonly occurred inside their houses. Previous studies have reported that tobacco smoke exposure is associated with impaired respiratory defence mechanisms, reduced macrophage function, and increased susceptibility to TB infection.[5,6] Bates et al. and Lin et al. reported that both active and passive smoking significantly increased the risk of TB infection and disease progression.[5,6] Among people living with HIV, smoking is associated with increased respiratory infections and poorer clinical outcomes.[9,10] The high prevalence of household smoking observed in this study highlights the potential importance of addressing children's exposure to second-hand smoke within broader TB-HIV prevention and health promotion efforts.

### B. Haematological and Immunological Findings

Most participants demonstrated relatively normal haematological profiles. Only one respondent experienced anemia, while mild abnormalities in hematocrit, erythrocyte count, and leukocyte count were observed in a small number of participants. These findings differ

from those of previous studies that reported high frequencies of haematological abnormalities among HIV-infected individuals.

Parinitha and Kulkarni reported that anaemia occurred in 84% of HIV patients, while lymphopenia and thrombocytopenia were identified in 65.2% and 18% of patients, respectively.[15] Similarly, de Santis et al. found that anemia was common among HIV-infected individuals and was associated with lower CD4 counts and disease progression.[16] The relatively normal haematological findings observed in this study may reflect the clinical status of participants at the time of assessment.

Immunological findings also demonstrated a relatively preserved immune status among most participants. Most respondents had CD4 counts above 500 cells/μL, although one respondent showed marked immunosuppression with a CD4 count of 338 cells/μL and a CD4 ratio of 0.17. HIV infection is characterized by the progressive depletion of CD4 lymphocytes and expansion of CD8 lymphocytes, leading to an inversion of the CD4 ratio. McBride and Striker described the CD4 ratio as an important marker of immune dysfunction and disease progression in PLHIV.[17] Likewise, Lu et al. reported that low CD4 ratios were associated with persistent immune dysregulation, despite treatment.[18]

The low CD4 count observed in one respondent may indicate an increased susceptibility to opportunistic infections, including TB. Previous studies have demonstrated that declining CD4 counts are strongly associated with an increased risk of TB among HIV-infected individuals.[1,2] These findings support the continued importance of immunological monitoring in routine HIV care, particularly among children with evidence of immunosuppression.

### C. Urinary Abnormalities

Most respondents had normal urine examination results. Only one participant demonstrated albuminuria and one participant had elevated leukocyte esterase levels. Although uncommon, these findings may warrant further clinical evaluation because urinary abnormalities have been reported among children living with HIV.

Renal complications are recognized manifestations of HIV infection and may result from direct HIV-associated nephropathy, chronic inflammation, opportunistic infections, or antiretroviral therapy.[20] Antonello et al. reported that pathological proteinuria was associated with HIV disease severity and lower CD4 count.[19] The relatively low prevalence of albuminuria observed in this study may be related to the relatively preserved immune status of most participants.

Although severe renal abnormalities were not observed, routine urine examination remains important because early renal impairment may occur without clinical symptoms. Routine urine examination may provide useful clinical information for monitoring children living with HIV.

### D. Vitamin Deficiencies among Children with HIV and TB–HIV Co-infection

Vitamin D insufficiency was the most common nutritional abnormality identified in this study. Most respondents had serum 25-hydroxyvitamin D levels below the recommended threshold of 30 ng/mL, and two participants demonstrated vitamin A deficiency.

Vitamin D plays a critical role in innate and adaptive immune responses, including macrophage activation and antimicrobial activity against *Mycobacterium tuberculosis*.[11,12] Previous studies have consistently reported high rates of vitamin D deficiency among people living with HIV. Lake and Adams reported that low vitamin D levels were associated with HIV-related factors, antiretroviral therapy use, disease severity, and mortality.[11] In addition, vitamin D deficiency has been linked to impaired immune function and increased susceptibility to opportunistic infections, including TB.[13,14]

Vitamin A deficiency was observed in two participants in this study. Vitamin A is essential for immune regulation, maintaining epithelial integrity, and lymphocyte function. Previous studies have reported associations between vitamin A deficiency, impaired immune responses, and increased susceptibility to

infectious diseases. Although less common than vitamin D deficiency in this study, inadequate vitamin A status may warrant attention in the nutritional assessment of children living with HIV.

Overall, the high prevalence of vitamin D insufficiency observed in this study highlights the importance of routine nutritional assessment of children with HIV and TB-HIV co-infection. Nutritional assessment and appropriate nutritional support may be considered as part of comprehensive clinical management for children living with HIV and TB-HIV, although further studies are needed to better understand their potential impact on health outcomes.

### E. Strengths and Limitations

This study provides important preliminary information regarding environmental conditions, laboratory findings, and micronutrient status of children with HIV and TB-HIV co-infection in Indonesia. However, this study has several limitations. First, the study included a relatively small sample size, which limits the generalizability of its findings. Second, the cross-sectional design precludes causal inference between environmental or nutritional factors and the disease outcomes. Finally, the study was conducted at a single health facility and may not represent the broader population of children living with HIV in Indonesia.

## Conclusions

Most household environmental conditions among children with HIV and TB–HIV co-infection met the recommended standards, although inadequate household lighting and exposure to second-hand cigarette smoke were common. Most participants demonstrated relatively preserved haematological and immunological profiles, while urinary abnormalities were uncommon. Vitamin D insufficiency was the most prevalent micronutrient abnormality, followed by vitamin A deficiency in a small number of participants. These findings provide descriptive information on environmental conditions, laboratory profiles, and micronutrient status among children living with HIV and TB–HIV in Semarang, Indonesia.

## Acknowledgement

The authors would like to thank the Directorate of Research and Community Service, Ministry of Research, Technology, and Higher Education of the Republic of Indonesia for funding this study through the Beginner Lecturer Research Grant Scheme (PDP) in 2017. The authors also express their gratitude to the Pulmonary Health Center of Semarang, all the study participants and their families, and the research assistants who supported data collection and laboratory examinations.

The authors acknowledge the contribution of the late Dr. Praba Ginandjar, who was involved in the conception and implementation of this study.

## References

1. World Health Organization. Tuberculosis and HIV. Geneva: World Health Organization; 2021.
2. Tornheim JA, Dooley KE. Tuberculosis associated with HIV infection. Microbiol Spectr. 2017;5(1):TNMI7-0028-2016.
3. UNAIDS. Global AIDS Update 2024: The urgency of now. Geneva: Joint United Nations Programme on HIV/AIDS; 2024.
4. Embree J. The impact of HIV/AIDS on children in developing countries. Paediatr Child Health. 2005;10(5):261-263.
5. Bates MN, Khalakdina A, Pai M, Chang L, Lessa F, Smith KR. Risk of tuberculosis from exposure to tobacco smoke: a systematic review and meta-analysis. Arch Intern Med. 2007;167(4):335-342.
6. Lin HH, Ezzati M, Murray M. Tobacco smoke, indoor air pollution and tuberculosis: a systematic review and meta-analysis. PLoS Med. 2007;4(1):e20.
7. MacLachlan JH, Lavender CJ, Cowie BC. Effect of latitude on seasonality of tuberculosis, Australia, 2002–2011. Emerg Infect Dis. 2012;18(11):1879-1881.
8. Koh GC, Hawthorne G, Turner AM, Kunst H, Dedicoat M. Tuberculosis

incidence correlates with sunshine: an ecological 28-year time series study. PLoS One. 2013;8(3):e57752.
9. Marshall MM, McCormack MC, Kirk GD. Effect of cigarette smoking on HIV acquisition, progression, and mortality. AIDS Educ Prev. 2009;21(Suppl 3):28-39.
10. Miguez-Burbano MJ, Burbano X, Ashkin D, Pitchenik A, Rodriguez A, Pineda L, et al. Impact of tobacco use on the development of opportunistic respiratory infections in HIV seropositive patients on antiretroviral therapy. Addict Biol. 2003;8(1):39-43.
11. Lake JE, Adams JS. Vitamin D in HIV-infected patients. Curr HIV/AIDS Rep. 2011;8(3):133-141.
12. Hewison M. Vitamin D and immune function: an overview. Proc Nutr Soc. 2012;71(1):50-60.
13. Mehta S, Mugusi FM, Bosch RJ, Aboud S, Chatterjee A, Finkelstein JL, et al. Vitamin D status and TB treatment outcomes in adult patients in Tanzania. BMJ Open. 2013;3:e003703.
14. Villamor E. A potential role for vitamin D on HIV infection? Nutr Rev. 2006;64(5 Pt 1):226-233.
15. Parinitha SS, Kulkarni MH. Haematological changes in HIV infection with correlation to CD4 cell count. Australas Med J. 2012;5(3):157-162.
16. de Santis GC, Brunetta DM, Vilar FC, Brandão RA, de Albernaz Muniz RZ, de Lima GM, et al. Hematological abnormalities in HIV-infected patients. Int J Infect Dis. 2011;15(12):e808-e811.
17. McBride JA, Striker R. Imbalance in the game of T cells: what can the CD4/CD8 T-cell ratio tell us about HIV and health? PLoS Pathog. 2017;13(11):e1006624.
18. Lu W, Mehraj V, Vyboh K, Cao W, Li T, Routy JP. CD4:CD8 ratio as a frontier marker for clinical outcome, immune dysfunction and viral reservoir size in treated HIV infection. J Int AIDS Soc. 2015;18:20052.
19. Antonello VS, Antonello ICF, Grossmann TK, Tovo CV. Proteinuria is associated with HIV disease and viral suppression. Rev Inst Med Trop Sao Paulo. 2015;57(5):409-413.
20. Wyatt CM, Klotman PE. HIV-associated nephropathy in the era of antiretroviral therapy. Am J Med. 2007;120(6):488-492.