

Evaluation of a zero-dose child who missed multiple vaccination opportunities in the urban area of Arsi zone in Oromia region: Gaps in service integration

Abyot Bekele Woyessa^{1,2,✉}, Tesfaye Deti Gelmessu¹, Zenebu Begna Bayissa³, Mekdes Tsegaye¹, Bekana Tolera¹, Birhanu Kenate Sori¹, Abebe Bekele Hurissa¹, Dashe Negawo¹, Paulos Samuel¹, Aklilu Fikadu Tufa¹, Getinet Argaw¹, Tatek Bogale Anbessie²

¹Oromia Regional Health Bureau, Addis Ababa, Ethiopia, ²African Field Epidemiology Network, Addis Ababa, Ethiopia, ³Ambo University School of Medicine and Health Science, Ambo, Ethiopia

✉Abyot Bekele Woyessa, Oromia Regional Health Bureau, Addis Ababa, Ethiopia and African Field Epidemiology Network, Addis Ababa, Ethiopia,
| Email: awoyessa@afenet.net | ORCID: 0000-0003-3585-1625

Article history:

Received: 17 January 2026

Accepted: 08 April 2026

Published: 10 April 2026

Abstract

Introduction: Children with special needs often miss essential health services, including routine immunisation, particularly in low- and middle-income countries. This case investigation examines the factors contributing to a zero-dose status in a child born with bilateral clubfoot in an urban area of the Arsi zone in Oromia Region, despite multiple contacts with a health facility.

Methods: A three-year-and-four-month-old boy born with bilateral clubfoot who had not received any routine childhood vaccinations was identified during house-to-house monitoring for an integrated measles supplementary immunisation campaign. Data were collected through interviews with the mother and health workers, review of medical records, and direct observation.

Results: The child missed 21 vaccination opportunities across health facilities and community service points and remained zero-dose at three years and four months of age. During each health facility visit, both health workers and the mother focused solely on the primary purpose of the visit and the child's vaccination status was never assessed. Contributing factors included a lack of service integration, limited mother awareness of the vaccination schedule, and concerns related to stigma and social discrimination associated with the child's conditions.

Conclusions: This case report suggests that children with different degrees of birth defects may miss essential health services, including routine immunisation, even when they have frequent contact with health facilities. Strengthening service integration at all points, including rehabilitation centres, assessing vaccination status of all visiting children regardless of the purpose of their visits, and enhancing health workers' and caregivers' awareness are critical to preventing zero-dose status and reducing missed opportunities for vaccination.

Keywords: Zero dose, missed opportunity for vaccination, vaccine equity, service integration, immunisation, supplementary immunisation activities

Citation

Suggested citation: Woyessa AB, Gelmessu TD, Bayissa ZB, Tsegaye M, Tolera B, Kenate Sori B, Hurissa AB, Negawo D, Samuel P, Fikadu Tufa A, Argaw G, Anbessie TB. Evaluation of a zero-dose child who missed multiple vaccination opportunities in the urban area of Arsi zone in Oromia region: Gaps in service integration. *J. Interv. Epidemiol Public Health* [Internet]. 2026 Apr 10;9(2):59. doi: 10.37432/jieph-d-26-00013

Copyright statement

©Abyot Bekele Woyessa et al. *Journal of Interventional Epidemiology and Public Health* (ISSN: 2664-2824). This is an Open Access article distributed under the terms of the Creative Commons Attribution 4.0 International License (<https://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Introduction

Ethiopia has been providing routine childhood vaccinations through the Expanded Program on Immunization (EPI) since 1980 to reduce mortality and morbidity from vaccine-preventable diseases. At inception. The EPI program included six vaccines: Bacille Calmette-Guerin (BCG), measles-containing vaccine (MCV), oral polio vaccine (OPV), diphtheria, pertussis, and tetanus [1]. Currently, 13 antigens are provided during the first and second year of life in Ethiopia [2,3].

Globally, approximately one in seven children does not receive the first dose of the pentavalent vaccine by their first birthday, which is commonly referred to as a zero-dose [4]. In 2023, 14.5 million infants did not receive the initial pentavalent vaccine dose, indicating significant gaps in access to immunisation services. However, among the estimated zero-dose children, 7.5 million are truly zero-dose, suggesting that 46.5% of zero-dose children have had at least one contact with the immunisation system [5]. The lack of adequate information to caregivers is demonstrated as one of the contributing factors for zero doses [6]. An additional 6.5 million are under vaccinated. Of the 21 million under- and unvaccinated children, about 60% live in 10 countries: Afghanistan, Angola, the Democratic Republic of the Congo, Ethiopia, India, Indonesia, Nigeria, Pakistan, Sudan, and Yemen [7]. One of the factors attributed to zero-dose and under-vaccination is a missed opportunity for vaccination. Sick child [8] and child delivered at home [9] were mostly zero-dose. Increasing attention is being given to reach children who fail to receive routine vaccinations, commonly designated as zero-dose children.

Children with disabilities experience substantial immunisation gaps [10]. However, data on vaccination coverage among children with specific congenital anomalies such as clubfoot remain extremely limited. Specific evidence from Fiji indicated that about half of the children with different forms of disability had not completed essential vaccine doses [11]. Monitoring vaccine access and utilisation equity for all children, regardless of their health state, including mental and physical disabilities, and where they reside, is an important step toward tailoring relevant programs and policies that allow for direct resource allocation to target missed children and communities.

Clubfoot, a common congenital foot deformity, can be associated with various taboos and stigmas, particularly in certain cultures. These could delay timely treatment and create psychosocial challenges for affected families. Children with disabilities continue to experience significant gaps in immunisation coverage, driven by multilevel barriers at the individual, health system, and societal levels [10]. Unlike other vulnerable and medically at-risk groups, strategies to improve vaccine uptake in

people with physical disabilities, who face considerable access and acceptance barriers, have not been explored [12].

We described the profile of a zero-dose child with clubfoot by examining his vaccination history, patterns of health facility visits, the types of services he received, caregiver perceptions of vaccination services, and the conceptual barriers experienced within the health system. This case study focuses on how these factors collectively contributed to multiple missed vaccination opportunities at health service points. The findings of this study will inform the regional health bureau's efforts in formulating context-specific interventions aimed at addressing zero-dose prevalence and minimising missed opportunities for vaccination through ensuring equitable vaccination services for children with disabilities.

Methods

Study settings and period

A descriptive case study was conducted in urban areas of the Arsi zone, Oromia region, in May 2025. The Arsi zone is located in the central part of the region and consists of 28 districts. Health services in the zone are delivered through a network of 9 hospitals, 109 health centres, and 547 health posts.

Case detection

The case was detected during supportive supervision of integrated measles supplementary vaccination activities. We conducted house-to-house monitoring to check that all target children received the measles campaign dose. During the visit, a male child aged 3 years and 4 months was observed playing outdoors approximately 200 meters from the campaign vaccination post. The child had no finger marks on his little finger, which is a typical sign used as proof of receiving the campaign dose despite being in the target age group. We contacted the mother of the child and asked her why the child did not receive the vaccination being given in the community. She reported that she did not hear about the ongoing vaccination campaign. We further asked her if the child has a card for routine vaccination. The mother reported the child had never been vaccinated. Upon further inquiry into the reasons for non-vaccination, she explained that the child was born with a congenital condition in his feet and was undergoing treatment by the time he was supposed to take the vaccination. We realised that the child was zero dose, and again, he missed the campaign and catch-up doses while he was eligible.

Data collection

Data used for this investigation were collected using structured interview questions administered to the child's mother. The questionnaire captured information on the

mother's antenatal care (ANC) experiences, her awareness of vaccines and vaccine-preventable diseases, sources of vaccination information, the child's vaccination history, and the health facilities visited since birth. Healthcare workers at the health facilities attended by the child were also interviewed to gather information on routine immunisation delivery practices. These interviews covered topics such as the vaccination schedule, procedures for assessing vaccination status during all child health visits, and routine documentation practices. Interviews were conducted in the local language and then translated into English. Additionally, medical records of both the child and mother at the outpatient and orthopaedics departments were reviewed to obtain vaccination histories and the frequency of health facility visits. The child's medical record number, full name, date of birth, mother's name, and address were used to accurately identify and retrieve the relevant records from the facility databases. Reviewing the medical records also helped to reduce potential recall bias and strengthen the reliability of the collected data

Definitions

Zero-dose: A child who has not received even a single vaccine dose. For operational purposes, Gavi defines a zero-dose child as an infant who has not received the first dose of diphtheria, tetanus, and pertussis-containing vaccine (DTP1) by the end of his/her first year of life [13].

Missed opportunity for vaccination: Any contact of an eligible child that is not fully or partially vaccinated and free of contraindication to vaccine with a health service that does not result in the person receiving all the required vaccinations for which s/he is eligible [14].

Ethics approval

The assessment was conducted in accordance with standard ethical guidelines on program assessments. The protocol underwent scientific and ethical review and was approved by the Oromia Regional Health Bureau Ethical Review Board and given a certificate of approval letter with referral number BFO/HQ/261/17. We also obtained permission at each level of the health system.

The consent script was read aloud in the local language to the child's mother. The purpose and content of the study, data confidentiality, utilisation, and publication plan were explained to her. The right to ask questions on the study contents and objective, decline participation, and withdraw at any time was also given to her. Based on the information provided, she agreed to participate and provided written consent. All identifiable information, including the names of the mother and child, photographs, the name of the health facility, and precise location details beyond the zone level, was excluded from all reports to ensure confidentiality.

Results

Case description

The case involves a baby boy born on December 6, 2021, in an urban area of the Oromia region. He is the second child in the family and has an older and a younger sister. The mother reported attending the health facility two to three times for antenatal care during each of her pregnancies. Both of his sisters were delivered in health facilities; however, this child was born at home following a quick labour while the mother was waiting for transportation to reach a health facility for skilled birth attendance.

Immediately after birth, the mother noticed an abnormality in the baby's feet. She closely observed the condition for three days before informing her husband. Concerned about the appearance of their newborn's feet and uncertain about its implications, the parents decided to seek medical care at a nearby health facility to determine whether treatment was available.

Missed opportunity for birth doses

On December 13, 2021, seven days after birth, the child was taken by his parents to the health centre where the mother had previously received antenatal care, seeking consultation regarding a congenital condition affecting his feet. During the visit, the health worker conducted a physical examination, diagnosed the child with clubfoot, and referred the family to a referral hospital for free treatment. They did not assess the vaccination status of the child, as the purpose of the visit was a non-vaccination service.

However, the child was eligible for the OPV birth dose and BCG on this visit. Health workers at each service point are expected to assess the vaccination status of all children presenting to the health centre, irrespective of the purpose of their visits. The vaccinator at the health centre demonstrated clear knowledge of the national vaccination schedule, including the administration of birth doses. It was also reported that the health centre has daily vaccination sessions. However, the routine assessment of the vaccination status of children presenting for non-vaccination services is not a common practice. As a result, the child missed opportunities to receive BCG and OPV birth doses, despite being age-eligible at the time of the visit.

Missed multiple vaccination opportunities

The child underwent clubfoot treatment at a referral hospital supported by Hope Walks, a faith-based non-governmental Organization. The hospital has a dedicated service point for clubfoot management and minor surgery procedures. Unlike acute illnesses, clubfoot requires extended care, often involving multiple visits over several months or years. This child was first seen at the

referral hospital at 14 days of age.

According to the national vaccination schedule, the child was still eligible to receive the BCG and OPV birth doses on this initial hospital visit. Upon arrival at the clubfoot service point of the hospital, the parents were welcomed and praised for seeking timely care for a treatable congenital deformity. They were provided with a clear explanation of the treatment plan and the anticipated duration of care required to correct the child's foot conditions.

During this visit, health workers conducted a clinical assessment using the standard clubfoot assessment and recording form, which includes a section for consent for treatment, contact information, family history, referral details, diagnosis, and physical examination findings. However, the form did not include a section for documenting the child's vaccination status. Consequently, the health workers did not inquire about or verify the child's vaccination history, assuming that vaccinations had been administered elsewhere. As a result, the child missed a second opportunity to receive the BCG and OPV birth dose despite being eligible and present in a hospital that provided routine vaccination every day.

Following the initial assessment, a follow-up visit was scheduled for when the child reached 21 days of age to initiate treatment. The parent returned with the child to the hospital as instructed. During this visit, the health workers started providing initial treatment to correct the child's foot condition. Although the child was eligible to receive the BCG vaccine on this date, it was not administered again. The treatment included massage therapy, casting, surgical intervention, and bracing, necessitating multiple hospital visits over an extended period.

By the time of assessment at three years and four months of age, the child had made 18 subsequent visits to the hospital for clubfoot treatment. Through this comprehensive care, he was effectively treated for a potentially lifelong physical disability, preventing the future social, psychological, and economic consequences associated with untreated clubfoot. However, across all encounters, his vaccination status was never assessed at any service point. Consequently, despite multiple opportunities for routine and catch-up vaccination, the child remained entirely unvaccinated due to a lack of service integration between the clubfoot treatment unit and the immunisation services. As a result, although the child was cured of a disabling congenital condition, he remained vulnerable to life-threatening and crippling vaccine-preventable diseases such as measles and poliomyelitis.

Missed campaign and catch-up doses

An integrated measles supplementary immunisation campaign was conducted in May 2025, targeting all children under five years of age. Children aged 0-11 who

had missed timely routine vaccination were eligible to receive their pending doses, while those aged 12-59 who had missed one or more vaccine doses except BCG were eligible for catch-up vaccinations. Additionally, all children aged 9-59 months qualified for the measles campaign dose. The campaign was delivered through fixed and temporary posts in the communities.

In the area where this child resided, a temporary vaccination post was set up at a school approximately 200 meters from his home. However, the child's parent was unaware of the vaccination campaign. Other community members also reported similar gaps in awareness. House-to-house social mobilisation activities were not conducted; instead, information about the campaign was disseminated solely through megaphone announcements. Due to these inadequate social mobilisation strategies, several children in the community, including this child, missed not only the measles dose but also other services offered during the campaign, such as catch-up immunisations, vitamin A supplementation, and deworming treatments.

At three years and four months of age and having never received any vaccine, the child was still eligible for all routine catch-up doses, except BCG and rotavirus vaccines, which are restricted to children under one year and two years of age, respectively. Following the relocation of the vaccination post, a supervisory team comprising representatives from regional, zonal, and district health offices identified that this child, along with several others in the community, had not received the measles campaign dose. The supervisory team recommended that the vaccination team return to the community to reach the missed children and also reported the issue to the district health authorities. Despite these recommendations, the vaccination team did not revisit the area. As a result, the child, his younger sister, and many more children in the community missed the opportunity to receive the measles campaign dose, as well as catch-up vaccinations. The detailed missed opportunities are described in Table 1.

Mother's perception and practice

The child's mother believed that vaccination protects children from various illnesses, including eye infections and scabies. She reported learning about vaccination from her own parents and community members and demonstrated her childhood BCG vaccination scar as evidence that vaccination is a common practice in the community. She understood that childhood vaccination typically begins at 45 days of age and was unaware of the existence of birth dose vaccination. Based on this understanding and her prior experience, she ensured that her first daughter received all recommended vaccinations and adhered to the immunisation schedule for her third child. However, she was unable to vaccinate her second child due to his congenital foot condition.

Table 1. Lists of health facility visit by date and missed opportunities for vaccination at each contact

Visits	Type of visited HF	Service obtained	Date	Missed vaccine doses	Description
1st	Health Center	Consultation	13-Dec-21	OPV birth dose and BCG	Routine doses
2nd	Hospital	Consultation	21-Dec-21	OPV birth dose and BCG	Routine doses
3rd	Hospital	Manipulation and casting	22-Dec-21	BCG	Routine dose
4th	Hospital	Manipulation and casting	29-Dec-21	BCG	Routine dose
5th	Hospital	Manipulation and casting	5-Jan-22	BCG	Routine dose
6th	Hospital	Brace Application	23-Feb-22	BCG, OPV1, Penta1, PCV1, Rota1	Routine doses
7th	Hospital	Brace Application	9-Mar-22	BCG, OPV1, Penta1, PCV1, Rota1	Routine doses
8th	Hospital	Brace Application	5-Apr-22	BCG, OPV1, Penta1, PCV1, Rota1	Routine doses
9th	Hospital	Brace Application	4-May-22	BCG, OPV1, Penta1, PCV1, Rota1	Routine doses
10th	Hospital	Brace Application	1-Jun-22	BCG, OPV1, Penta1, PCV1, Rota1	Routine doses
11th	Hospital	Brace Application	17-Aug-22	BCG, OPV1, Penta1, PCV1, Rota1	Routine doses
12th	Hospital	Brace Application	9-Nov-22	BCG, OPV1, Penta1, PCV1, IPV1, Rota1, MCV1	Routine doses
13th	Hospital	Brace Application	25-Jan-23	OPV1, Penta1, PCV1, IPV1, Rota1, MCV1	Catch-up doses
14th	Hospital	Brace Application	29-Mar-23	OPV1, Penta1, PCV1, IPV1, Rota1, MCV1	Catch-up doses
15th	Hospital	Brace Application	5-Jul-23	OPV1, Penta1, PCV1, IPV1, Rota1, MCV1	Catch-up doses
16th	Hospital	Brace Application	10-Oct-23	OPV1, Penta1, PCV1, IPV1, Rota1, MCV1	Catch-up doses
17th	Hospital	Brace Application	23-Jan-24	OPV1, Penta1, PCV1, IPV1, MCV1	Catch-up doses
18th	Hospital	Maintenance (Bracing)	14-May-24	OPV1, Penta1, PCV1, IPV1, MCV1	Catch-up doses
19th	Hospital	Maintenance (Bracing)	16-Sep-24	OPV1, Penta1, PCV1, IPV1, MCV1	Catch-up doses
20th	Hospital	Maintenance (Bracing)	29-Jan-25	OPV1, Penta1, PCV1, IPV1, MCV1	Catch-up doses
21st	Campaign monitoring team	Awareness and advice	24-May-25	OPV1, Penta1, PCV1, IPV1, MCV1	Catch-up doses

The mother's primary concern after the child's birth was obtaining medical treatment to correct her child's foot deformity. She took the child to a nearby health facility seven days after delivery, where a health worker assessed the condition and diagnosed the child with clubfoot. She was advised to seek treatment at a referral hospital, which she did when the child was 15 days old. The treatment began when the child reached 21 days of age. By the time the child was 45 days of age, the age at which the mother believed routine immunisation should begin, the child was wearing a cast as per the clubfoot treatment. She expressed concern about how vaccination could be administered while the child was in a cast.

Throughout this period, the mother sought care exclusively at the referral hospital for the child's feet treatment. She also stated that she avoided having neighbours and extended family members see the child during the first three months of casting due to fear of stigma or negative reactions. After the casting phase was completed, the mother believed that the window for the routine vaccination schedule had already passed and assumed her child was no longer eligible for childhood vaccination.

Health facility practices

There was no integration of services at either the health centre or the referral hospital visited by the child and his

caregiver. When the parent first took the child to the health centre to seek medical consultation for the child's foot condition, the child was eligible to receive the routine birth dose vaccines. However, the opportunity to administer these vaccines was not utilised. Health workers focused solely on the presenting concern and did not assess the child's vaccination status. A similar pattern was observed at the referral hospital. Despite multiple follow-up visits for clubfoot treatment over an extended period, the child's vaccination status was never assessed at any service point. Health workers at the hospital perceived that the child may have received the vaccine at the referring health centre.

Discussion

Our investigation revealed that the zero-dose child, who was born with a birth defect in urban areas of the Oromia region, missed multiple vaccination opportunities while he had 21 contacts with health facilities and health workers. Children with certain health conditions were identified as less likely to receive or complete vaccine doses for which they were eligible [15,16]. People with disabilities have lower rates of immunisation uptake across a range of different vaccines [12]. As demonstrated in China, vaccination coverage in the special needs population group is too low to protect them from vaccine-preventable diseases through immunisation [17].

Probably different factors prohibited these groups from obtaining medical treatment and lifesaving vaccinations. Fear of stigma prevents children from seeking health services [18]. It also affects the willingness of parents to seek vaccinations for their children [10]. In our investigation, the mother of the child did not show the child to the neighbourhood and even to relatives until the child completed the treatment. They were disturbed by the child's foot condition and afraid of the community's feedback and perceptions. They took the child only to the treatment center to correct the child's foot, irrespective of the knowledge of the importance of the child's vaccination. They vaccinated their other two children, but failed to vaccinate the child with clubfoot. Hence, it was a fear of stigma that may prohibit this mother from vaccinating her child. Children with clubfoot could receive vaccinations to the areas of the body that are not covered by the cast, or even after treatment [19].

Similar to the case we are reporting, children with birth defects such as spina bifida are less likely to complete the vaccination schedule even when they have contact with health facilities for treatment [20]. A significant proportion of children with birth defects do not visit a health facility. They mostly stayed at home during their childhood. Only the tip of the iceberg visits the health facility for treatment. Even when they get a chance to visit a health facility, they probably obtain only the primary health service for which they visit.

For instance, the case we reported here had multiple visits to health facilities, including to the referral hospital for correction of clubfoot. He only received treatment for clubfoot, while the hospital also provides vaccination services every day. There is no vaccination service integration with the rehabilitation unit in the hospital. The health workers responsible for the treatment and correction of clubfoot did not check the vaccination status of the child, perceiving that the child had received the vaccine at the referring health facility. Hence, from a health facility perspective, this child missed multiple vaccination opportunities due to the lack of service integration and the lack of health workers' awareness.

This case investigation further illustrates how inadequate maternal knowledge and misconceptions can contribute to missed childhood vaccinations. The mother was unaware of birth doses, believed vaccination started at 45 days, and assumed the child was no longer eligible after missing the schedule. She also could not identify the diseases prevented by vaccines, reflecting a limited understanding of vaccine benefits. Her reliance on family and neighbours rather than healthcare providers suggests a lack of accurate, first-hand information. This highlighted a programmatic gap and needs further study to understand how social mobilisation and interpersonal communication are delivered at service points.

Actions taken

The investigation team counselled the parents on the importance of timely vaccination and facilitated the child's visit to the nearest health facility for catch-up immunization. The child received the first doses of pentavalent vaccine, Oral Polio Vaccine (OPV), Pneumococcal Conjugate Vaccine (PCV), Inactivated Polio Vaccine (IPV), and a measles-containing vaccine.

Rotavirus vaccine and BCG were not administered due to age restrictions. The health workers provided key health messages, explained the next appointment for completing the remaining doses, and issued a child vaccination card for future follow-up.

A key limitation of this report is its limited generalizability, since case reports cannot represent the broader population. Other limitations include the potential recall bias in the mother's account of what occurred during each visit, the lack of a comparison group, and the inability to determine whether the findings reflect systemic issues or isolated facility-level failures. However, the detailed investigation supported by information from the mother, healthcare workers, and medical record review provides valuable insights for immunisation programs and helps highlight potential gaps in service delivery for similar populations.

Conclusions

This case report suggests that children with congenital defects may experience inequitable access to health services, including vaccination, due to fear of discrimination, misconceptions, limited awareness, and poor service integration. These factors contribute to missed opportunities for immunization, even when children are already in contact with the health system for treatment or rehabilitation. Integrating routine immunization screening into rehabilitation and other clinical services may help reduce such missed opportunities. Further research is recommended to better understand the prevalence of zero-dose status and missed opportunities for vaccination among children receiving care for different degrees of disability at rehabilitation centres. Studies should also evaluate the cost-effectiveness of service integration and support the design of evidence-based interventions, including stigma-reduction strategies and improved service integration, to enhance vaccination coverage.

What is already known about this topic

- Children with different degrees of birth defects are missing health services, including routine immunisations, especially in low- and middle-income countries;
- Children born with birth defects, including clubfoot, are more likely to miss vaccination services even when they visit a health facility for medical care

What This Study Adds

- Lack of service integration at service points leads to a missed opportunity for vaccination.
- Stigma and fear of social discrimination may prevent parents of children with birth defects from seeking medical services,
- Ensuring service integration in health care settings, including rehabilitation centers, assessing vaccination status of all visiting children could minimize missed opportunities for vaccination, increase vaccination coverage, and improve timeliness.

Conflict of Interest

The authors of this work declare no competing interests.

Funding

The authors did not receive any specific funding for this work.

Acknowledgments

We would like to thank the parent of the child for providing information used to prepare this report. We also acknowledge health facilities and health workers for providing the required information and allowing the investigation team to review medical records.

Data availability statement

The datasets used to prepare this report are available at the Oromia Regional Health Bureau and can be obtained from the corresponding author upon reasonable request.

Authors' contributions

ABW: Conceived the idea, conducted investigation, analyzed and interpreted the findings, wrote the initial draft, conducted analysis, and prepared the graphics. TD: supported investigation. ZBB: framed and reviewed the manuscript. MT, BT, BK, ABH, YLT, GA, TBA, and MAK reviewed the manuscript. All authors reviewed and finalized the manuscript.

References

- [1] Belete H, Kidane T, Bisrat F, Molla M, Mounier-Jack S, Kitaw Y. Routine immunization in Ethiopia. *Ethiop J Heal Dev* [Internet]. 2017 Nov 9 [cited 2026 Apr 10];29(Special Issue 1):1-35. Available from:<https://ejhd.org/index.php/ejhd/article/view/1395>
- [2] Ministry of Health, Ethiopia. Routine Immunization Catch-up Vaccination Guidelines [Internet]. Addis Ababa (Ethiopia): Ministry of Health; 2022 Jan [cited 2026 Apr 10]. 30 p. Available from: https://hakimethio.org/wp-content/uploads/2024/09/Routine-Immunization-Catch-up-Vaccination-Guideline-_2022.pdf
- [3] Ministry of Health, Ethiopia. Ethiopia National Expanded Program on Immunization: comprehensive multi-year plan (2021-2025) [Internet]. Addis Ababa (Ethiopia): Ministry of Health; 2021 Jul [cited 2026 Apr 10]. 108 p. Available from:<https://hakimethio.org/wp-content/uploads/2024/09/Ethiopia-National-Expanded-Program-on-Immunization-V3.pdf>
- [4] Zero-dose: The children missing out on life-saving vaccines [Internet]. New York (NY): UNICEF; 2023 Apr [cited 2026 Apr 10]. Available from:<https://data.unicef.org/resources/zero-dose-the-children-missing-out-on-life-saving-vaccines/>
- [5] Wonodi C, Farrenkopf BA. Defining the Zero Dose Child: A Comparative Analysis of Two Approaches and Their Impact on Assessing the Zero Dose Burden and Vulnerability Profiles across 82 Low- and Middle-Income Countries. *Vaccines* [Internet]. 2023 Sep 28 [cited 2026 Apr 10];11(10):1543.doi:10.3390/vaccines11101543
- [6] Biks GA, Shiferie F, Tsegaye DA, Asefa W, Alemayehu L, Wondie T, Seboka G, Hayes A, RalphOpara U, Zelalem M, Belete K, Donofrio J, Gebremedhin S. In-depth reasons for the high proportion of zero-dose children in underserved populations of Ethiopia: Results from a qualitative study. *Vaccine: X* [Internet]. 2024 Jan [cited 2026 Apr 10];16:100454. doi:10.1016/j.jvaxc.2024.100454
- [7] Immunization Coverage Key Facts Overview [Internet]. Geneva (Switzerland): WHO; 2025 Jul 15 [cited 2026 Apr 10]. Available from:<https://www.who.int/news-room/fact-sheets/detail/immunization-coverage>
- [8] Ishoso DK, Mafuta E, Danovaro-Holliday MC, Ngandu C, Menning L, Cikomola AMW, Lungayo CL, Mukendi JC, Mwamba D, Mboussou FF, Manirakiza D, Yapi MD, Ngabo GF, Riziki RB, Aluma ADL, Tsobeng BN, Mwanga C, Otomba J, Lulebo A, Lusamba P, Nimpa MM. Reasons for Being “Zero-Dose and Under-Vaccinated” among Children Aged 12–23 Months in the Democratic Republic of the Congo. *Vaccines (Basel)* [Internet]. 2023 Aug 16 [cited 2026 Apr 10];11(8):1370. doi:10.3390/vaccines11081370
- [9] Nchinjoh SC, Saidu Y, Agbor VN, Mbanga CM, Jude Muteh N, Njoh AA, et al. Factors Associated with Zero-Dose Childhood Vaccination Status in a Remote Fishing Community in Cameroon: A Cross-Sectional Analytical Study. *Vaccines* [Internet]. 2022 Nov 30 [cited 2026 Apr 10];10(12):2052.doi:10.3390/vaccines10122052
- [10] Musuka G, Cuadros DF, Miller FD, Mukandavire Z, Dhliwayo T, Iradukunda PG, Mano O, Dzinamarira T. Immunization Coverage, Equity, and Access for Children with Disabilities: A Scoping Review of Challenges, Strategies, and Lessons Learned to Reduce the Number of Zero-Dose Children. *Vaccines* [Internet]. 2025 Mar 31 [cited 2026 Apr 10];13(4):377.doi:10.3390/vaccines13040377
- [11] Jahan I, Vakaloloma U, Perera S, Tuibeqa I, Devi R, Volavola L, May W, Wilson D, Tuimabu L, Power R, Woolfenden S, Danchin M, McIntyre S, Smithers-Sheedy H, Badawi N,

- Macartney K, Khandaker G, Sheel M. Vaccination and its social and behavioural drivers in children with disability in Fiji. *BMJ Glob Health* [Internet]. 2025 May 8 [cited 2026 Apr 10];10(5):e017510.doi:10.1136/bmjgh-2024-017510
- [12] O'Neill J, Newall F, Antolovich G, Lima S, Danchin M. Vaccination in people with disability: a review. *Human Vaccines Immunotherapeutics*. 2020 Jan 2;16(1):7–15.doi:10.1080/21645515.2019.1640556
- [13] Zero-dose children and missed communities [Internet]. Geneva (Switzerland): GAVI; 2025 May 15 [cited 2026 Apr 10]. Available from:<https://www.gavi.org/our-alliance/strategy/phase-5-2021-2025/equity-goal/zero-dose-children-missed-communities>
- [14] Jejaw M, Tafere TZ, Tiruneh MG, Hagos A, Teshale G, Tilahun MM, Negash WD, Demissie KA. Three in four children age 12–23 months missed opportunities for vaccination in Sub-Saharan African countries: a multilevel mixed effect analysis of demographic health and surveys 2016–2023. *BMC Public Health* [Internet]. 2025 Jan 7 [cited 2026 Apr 10];25(1):62.doi:10.1186/s12889-024-21273-3
- [15] Walker EJ, MacDonald NE, Islam N, Le Saux N, Top KA, Fell DB. Completeness and timeliness of diphtheria-tetanus-pertussis, measles-mumps-rubella, and polio vaccines in young children with chronic health conditions: A systematic review. *Vaccine* [Internet]. 2019 Mar 8 [cited 2026 Apr 10];37(13):1725–35.doi:10.1016/j.vaccine.2019.02.031
- [16] Masson A, Launay O, Delaisi B, Bassinet L, Remus N, Lebourgeois M, Chedevergne F, Bailly C, Foucaud P, Corvol H, deBlic J, Sermet-Gaudelus I. Vaccine coverage in CF children: A French multicenter study. *Journal of Cystic Fibrosis* [Internet]. 2015 Sep 7 [cited 2026 Apr 10];14(5):615–20.doi:10.1016/j.jcf.2015.04.006
- [17] Xu B, Zhang Y, Zhou C, Wang Q, Luan R. Vaccination coverage and immunization safety among children with special health status in Chongqing, China. *Human Vaccines Immunotherapeutics*. 2022 Dec 30;18(7):2138466.doi:10.1080/21645515.2022.2138466
- [18] Nayar US, Stangl AL, De Zaluondo B, Brady LM. Reducing Stigma and Discrimination to Improve Child Health and Survival in Low- and Middle-Income Countries: Promising Approaches and Implications for Future Research. *Journal of Health Communication* [Internet]. 2014 Sep 10 [cited 2026 Apr 10];19(suppl 1):142–63.doi:10.1080/10810730.2014.930213
- [19] Pittner DE, Klingele KE, Beebe AC. Treatment of Clubfoot With the Ponseti Method: A Comparison of Casting Materials. *Journal of Pediatric Orthopaedics* [Internet]. 2008 Mar [cited 2026 Apr 10];28(2):250–3.doi:10.1097/BPO.0b013e318164f8e7
- [20] Raddish M. The Immunization Status of Children With Spina Bifida. *Arch Pediatr Adolesc Med* [Internet]. 1993 Aug 1 [cited 2026 Apr 10];147(8):849–53.doi:10.1001/archpedi.1993.02160320051018
- [21] Zeng Y, Li X, Tian Y, Liu Y, Wang J, An Q, Yang C, Zhou B, Zhang L, Huang Y, Wang L. Timeliness of Routine Vaccination, Catch-Up Completion, and Immune Function in Chinese Children with Special Healthcare Needs: A Retrospective Cohort Study. *Vaccines* [Internet]. 2026 Jan 31 [cited 2026 Apr 10];14(2):149. doi:10.3390/vaccines14020149