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Research Article

A Description of BCG Scars from BCG Vaccination Recorded in the Health Records of 1-Year-Old Children at Posyandu Centers in the Raja Basa Indah Public Health Center District, Bandar Lampung City in 2013

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Abstract. Immunization is an important measure for preventing infectious diseases that should be administered from an early age to boost children's immunity against various dangerous diseases. One of the mandatory basic immunizations for infants is the Bacillus Calmette-Guérin (BCG) vaccine, which aims to prevent tuberculosis (TB). Following BCG vaccination, a scar typically forms at the injection site as a sign of the body's immune response to the vaccine. This study aims to determine the characteristics of BCG scars in children aged ≤ 1 year recorded in the KMS at the Posyandu in the Raja Basa Indah Public Health Center, Bandar Lampung City, in 2013. The study used a descriptive survey method with an observational approach. The study population consisted of 707 children, and the sample comprised 88 children selected using simple random sampling. Data collection was conducted through direct observation of the presence of BCG scars on the children's right upper arms and documentation based on the Health Development Card (KMS). Data analysis was performed using univariate analysis with SPSS version 16 and presented in the form of frequency distributions. The results showed that of the 88 children who had received BCG immunization, 67 children (76.1%) developed a BCG scar, while 21 children (23.9%) did not. The development of a BCG scar is influenced by several factors, such as the injection technique, vaccine dose, vaccine quality, and the child's immune system. This study shows that most children who have received the BCG vaccine develop a scar as a sign of successful immunization.

Keywords: BCG Scar; BCG Vaccination; KMS**;** Primary Immunization; Tuberculosis.

1. Introduction

Immunization is one of the public health programs that plays an important role in reducing morbidity and mortality rates among infants and children. Immunization programs

are implemented as a form of prevention against various dangerous infectious diseases. Through immunization, the body develops immunity against certain diseases so that the risk of complications and death can be minimized.

In Indonesia, the government has implemented the Expanded Program on Immunization (EPI) as an effort to improve the degree of public health. The program includes the provision of complete basic immunization for infants and toddlers. Complete basic immunization consists of BCG, DPT, polio, hepatitis B, and measles immunizations. One of the immunizations that must be administered to infants is the Bacillus Calmette Guerin or BCG immunization. Mandatory immunization is immunization that must be given to infants. Through the administration of mandatory immunization, infants will be protected against diseases that commonly attack them. Among the various types of immunizations included in mandatory immunization are one dose of BCG immunization, three doses of DPT immunization, four doses of polio immunization, one dose of measles immunization, and three doses of hepatitis B immunization. The target achievement for immunization coverage in the national immunization program for all types of immunization must reach 85%. In 2012, the coverage of basic immunization reached 98.5% for BCG immunization, 80.4% for hepatitis B immunization, 98.6% for DPT immunization, 95% for polio immunization, 93.8%, and 93.8% for measles immunization.

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Not all toddlers can have their immunization status identified. This is caused by several reasons, namely incomplete or unfilled records in the KMS, inability to present the KMS or child records because they were lost or not kept by the mother. Rajabasa Indah Public Health Center is located on Rambukah Street within the administrative area of Rajabasa Indah Subdistrict, Bandar Lampung City. The population within the working area of Rajabasa Indah Public Health Center consists of two major groups, namely foreign residents and migrant residents. It is estimated that 20% are native residents and 80% are migrant residents. The area of Rajabasa Public Health Center is 1,302 hectares spread across seven subdistricts with an average population density in Rajabasa Indah District of 26,067 inhabitants. The achievement of the immunization program at Rajabasa Indah Public Health Center in 2011 was HB immunization 82.6%, BCG 94.2%, polio 93.6%, DPT 92.8%, and measles 93.9%. The normal reaction of BCG bacteria in the body works very slowly. After 2 weeks, a small red swelling with a diameter of 10 mm will appear at the injection site. Then after 2–3 weeks, the swelling becomes a small abscess which later turns into a wound with a diameter of 10 mm. The wound will heal spontaneously and leave scar tissue (SCAR) with a diameter of 3–7 mm.

Immunization is one of the public health programs that plays an important role in reducing morbidity and mortality rates among infants and children. Immunization programs are implemented as a form of prevention against various dangerous infectious diseases. Through immunization, the body develops immunity against certain diseases so that the risk of complications and death can be minimized. In recent years, the implementation of immunization programs in Indonesia has continued to receive significant attention as part of national health development strategies aimed at improving child survival and reducing the burden of communicable diseases. The success of immunization programs is not solely determined by vaccine availability, but also by parental compliance, public awareness, and access to health services. Research conducted by Sinuhaji and Sembiring (2024) demonstrated that evaluating the success of health programs contributes significantly to improving BCG immunization coverage among infants aged 0–2 months. Furthermore, maternal compliance and awareness regarding childhood immunization schedules are closely associated with the completeness of immunization status in children aged 0–36 months (Duarsa et al., 2023). These findings indicate that strengthening preventive healthcare strategies through education and community participation remains essential in ensuring the effectiveness of immunization programs at the primary healthcare level.

In Indonesia, the government has implemented the Expanded Program on Immunization (EPI) as an effort to improve the degree of public health. The program includes the provision of complete basic immunization for infants and toddlers. Complete basic immunization consists of BCG, DPT, polio, hepatitis B, and measles immunizations. One of the immunizations that must be administered to infants is the Bacillus Calmette Guerin or BCG immunization. Mandatory immunization is immunization that must be given to infants. Through the administration of mandatory immunization, infants will be protected against diseases that commonly attack them. Among the various types of immunizations included in mandatory immunization are one dose of BCG immunization, three doses of DPT immunization, four doses of polio immunization, one dose of measles immunization, and three doses of hepatitis B immunization. BCG immunization specifically serves as an important preventive measure against tuberculosis, which remains one of the leading infectious diseases affecting children in developing countries. Educational interventions regarding the benefits of BCG immunization have also been shown to improve family understanding and participation in infant immunization programs (Rizka et al., 2026). In addition, maternal attitudes toward the appearance of scars or ulcers following BCG immunization significantly influence parental acceptance of the vaccine, as some parents perceive post-immunization scar formation as an adverse reaction rather than a normal immunological response (Prihartini, 2017). Therefore, improving public understanding regarding the normal physiological response following BCG immunization is essential to prevent misconceptions that may negatively affect immunization compliance. The target achievement for immunization coverage in the national immunization program for all types of immunization must reach 85%.

In 2012, the coverage of basic immunization reached 98.5% for BCG immunization, 80.4% for hepatitis B immunization, 98.6% for DPT immunization, 95% for polio immunization, 93.8%, and 93.8% for measles immunization. Not all toddlers can have their immunization status identified. This is caused by several reasons, namely incomplete or unfilled records in the KMS, inability to present the KMS or child records because they were lost or not kept by the mother. Rajabasa Indah Public Health Center is located on Rambukah Street within the administrative area of Rajabasa Indah Subdistrict, Bandar Lampung City. The population within the working area of Rajabasa Indah Public Health Center consists of two major groups, namely foreign residents and migrant residents. It is estimated that 20% are native residents and 80% are migrant residents. The area of Rajabasa Public Health Center is 1,302 hectares spread across seven subdistricts with an average population density in Rajabasa Indah District of 26,067 inhabitants. The achievement of the immunization program at Rajabasa Indah Public Health Center in 2011 was HB immunization 82.6%, BCG 94.2%, polio 93.6%, DPT 92.8%, and measles 93.9%. The normal reaction of BCG bacteria in the body works very slowly. After 2 weeks, a small red swelling with a diameter of 10 mm will appear at the injection site. Then after 2–3 weeks, the swelling becomes a small abscess which later turns into a wound with a diameter of 10 mm. The wound will heal spontaneously and leave scar tissue (SCAR) with a diameter of 3–7 mm. Conditions related to infant nutrition, breastfeeding practices, and parental caregiving behaviors also contribute to children's immune responses and overall health outcomes following immunization. Studies conducted in the Rajabasa area of Bandar Lampung highlighted that infant feeding practices and breastfeeding patterns remain important determinants of child health and immune resilience during early childhood (Juherman et al., 2022; Yulia Novika, 2019).

Based on the background description above, this study was conducted to determine the description of BCG scars in 1-year-old children recorded in the KMS at Posyandu within the working area of Raja Basa Indah Public Health Center, Bandar Lampung City, in 2013. This study focused on the frequency distribution of the occurrence and non-occurrence of BCG scars in children who had received BCG immunization. The study employed a descriptive survey method with research subjects consisting of 1-year-old children recorded in the KMS and who had received BCG immunization. The research was conducted at Posyandu within the working area of Raja Basa Indah Public Health Center, Bandar Lampung City, from December 2013 to February 2014. The results of this study are expected to provide benefits for researchers as a means of increasing knowledge and research experience, for educational institutions as an additional source of literature, for the community to improve understanding regarding BCG immunization and the occurrence of scars after injection, as well as for public health centers as input material regarding the importance of administering BCG immunization as an effort to prevent tuberculosis disease. In addition, this study is expected to serve as a reference for future research related to BCG immunization and the occurrence of BCG scars in children.

2. Preliminaries or Related Work or Literature Review

Immunization

Immunization originates from the word immune, which means resistant or protected. When a child is immunized, it means that the child is given immunity against a particular disease. A child may be immune to one disease, but not necessarily immune to other diseases. Immunization is a method of increasing a person's immunity to a disease so that if they are later exposed to the disease, they will not become ill. The purpose of immunization is to prevent the occurrence of certain diseases in individuals and eliminate those diseases within a community group. Immunization certainly provides benefits; for infants, immunization serves to protect babies whose immune systems are still highly vulnerable from diseases that may cause illness. Meanwhile, for families, it is beneficial in reducing anxiety and preventing high medical expenses when children become ill. Infants and children who receive complete basic immunization will be protected from several dangerous diseases and can prevent transmission to younger siblings, older siblings, and friends around them. Meanwhile, the benefit for the country is undoubtedly to improve the degree of public health and create a strong and intelligent nation to continue national development.

BCG Immunization (Bacillus Calmette Guerin)

Bacillus Calmette Guerin (BCG) immunization is an immunization administered to induce active immunity against tuberculosis (TB), which is a contagious infectious disease that generally attacks the lungs and is caused by the bacterium Mycobacterium tuberculosis. This disease remains one of the public health problems due to its rapid transmission and its potential to cause serious complications in children if not prevented early. Therefore, BCG immunization is one of the basic immunizations that must be administered to infants as a preventive measure against tuberculosis.

BCG immunization is administered only once and does not require repetition or a booster. This is because the BCG vaccine contains live attenuated bacteria capable of stimulating the formation of sufficiently strong and long-lasting antibodies within the body. This differs from several other types of vaccines that use killed bacteria and therefore require repeated administration to maintain the level of body immunity.

BCG immunization is recommended to be administered as early as possible, particularly to infants aged 0–3 months. If the immunization is administered after the age of 3 months, it is recommended to perform a Mantoux or tuberculin test first to determine whether the infant has been exposed to Mycobacterium tuberculosis bacteria. BCG immunization is only administered if the test result is negative. In infants living in the same household as tuberculosis patients or frequently interacting with TB patients, BCG immunization should preferably be administered immediately after birth so that the infant obtains earlier protection against the disease.

The method of administering BCG immunization is performed intradermally or intracutaneously, namely injection into the skin layer of the upper right arm precisely in the insertion area of the Musculus deltoideus in accordance with the recommendations of the World Health Organization (WHO). Injection is not recommended in other body parts such as the thigh or buttocks because the deltoid area has thinner subcutaneous tissue, making intradermal injection easier to perform and the immunization results more optimal.

The side effects of BCG immunization are generally rare and mild. The reaction that frequently appears is the formation of a small lump at the injection site which later develops into a small wound and leaves a scar or scar tissue. In some cases, swelling of the lymph nodes around the armpit or lower neck may occur, but the condition usually heals spontaneously although it requires a relatively long period of time.

BCG Scar

A scar is scar tissue formed on the skin after the wound healing process. In BCG immunization, the scar becomes one of the indicators of successful vaccine administration. After immunization, a small pus-filled boil usually appears at the injection site within approximately 4–6 weeks. The reaction generally does not cause pain or fever. The boil will heal spontaneously and leave a mark in the form of scar tissue or a scar on the infant's upper right arm. The appearance of this scar indicates that the body has responded to the administered BCG vaccine.

The process of scar formation begins with the appearance of a lump at the injection site which later develops into a small pus-filled boil. The boil is not recommended to be squeezed because it may cause infection or create new wounds on the skin. Therefore, the boil should be allowed to rupture and heal naturally. After the healing process is completed, a small lump or mark resembling a mosquito bite will appear as an indication of successful BCG immunization. The scar usually becomes visible at the earliest one month and at the latest three months after the immunization is administered.

The absence of a BCG scar may be influenced by several factors. One of the most common factors is improper injection technique. An injection administered too deeply may cause the vaccine not to function optimally within the skin layer. In addition, an insufficient vaccine dose may also affect the formation of the body's immune response. Another influencing factor is improper vaccine storage, resulting in decreased vaccine quality and reduced effectiveness when administered to infants. The condition of the infant's immune system also affects the formation of the BCG scar.

Infants with low immune systems may not produce an optimal immune response to the vaccine. In addition, low antibody levels produced by the infant's body may also cause the scar not to appear after immunization. Although the scar does not form, BCG immunization generally does not need to be repeated because antibodies against tuberculosis bacteria have actually been formed, although the levels are relatively lower compared to infants who experience scar formation.

TB (Tuberculosis)

Tuberculosis is one of the infectious diseases that remains a public health problem and is among the leading causes of death after cardiovascular diseases and respiratory tract diseases. Among infectious diseases, tuberculosis even ranks first as a cause of death. This disease is caused by the bacterium Mycobacterium tuberculosis, which generally attacks the lungs and is easily transmitted through droplets from infected individuals. The high incidence rate of tuberculosis necessitates preventive efforts from an early age, one of which is through immunization.

Disease prevention through immunization or vaccination is an action aimed at increasing a person's resistance to certain diseases. Immunization aims to stimulate the immune system so that it is capable of recognizing and fighting disease-causing pathogens if they enter the body at some point in the future. Vaccination to prevent tuberculosis is performed through the administration of the Bacillus Calmette-Guerin (BCG) vaccine. The BCG vaccine contains live attenuated bacteria capable of stimulating the formation of body immunity without causing the disease.

The infant's immune system has actually begun to develop since birth. Therefore, administering BCG immunization as early as possible will help induce an earlier immune response, particularly the cellular immune response which plays an important role in combating tuberculosis infection. This cellular immune response is more dominant than the humoral immune response in providing protection against TB disease. With the formation of a good immune response, the infant's body is expected to possess resistance against Mycobacterium tuberculosis infection so that the risk of tuberculosis can be reduced from an early stage.

The administration of BCG immunization is currently recognized as being capable of providing protection against severe forms of tuberculosis in children, such as miliary tuberculosis that spreads throughout the body and tuberculous meningitis that attacks the membranes of the brain. Both types of disease carry the risk of severe complications and may even cause death in children if not properly prevented. Therefore, BCG immunization constitutes an important component of the complete basic immunization program for infants and children.

The incidence of tuberculosis is influenced by various factors, both individual and environmental. Several factors associated with the incidence of TB include age, gender, BCG immunization status, nutritional status, history of low birth weight infants (LBWI), and breastfeeding. These factors may affect a child's resistance to tuberculosis infection and therefore need to be considered in efforts to prevent and control TB disease in children.

3. Materials and Method

This study employed a descriptive survey research method, namely research conducted to describe or illustrate a phenomenon occurring within the community, particularly those related to health problems in certain groups. The descriptive method was used to provide an overview of existing conditions without administering any specific treatment to the research subjects. In this study, the descriptive survey method was used to determine the description of BCG scars in BCG immunization recorded in the KMS of 1-year-old children at Posyandu within the working area of Raja Basa Indah Public Health Center, Bandar Lampung City, in 2013. The study was conducted from December 2013 to February 2014 at Posyandu within the working area of Raja Basa Indah Public Health Center, Bandar Lampung City. The population in this study consisted of all 1-year-old children who had received BCG immunization and were recorded in the Kartu Menuju Sehat (KMS) at Posyandu within the working area of Raja Basa Indah Public Health Center, Bandar Lampung City, totaling 707 children.

The sample in this study consisted of 1-year-old children who had received BCG immunization and were recorded in the KMS at Posyandu within the working area of Raja Basa Indah Public Health Center, Bandar Lampung City. The sampling technique used in this study was simple random sampling (Sugiyono, 2005). Data analysis in this study was conducted univariately. Univariate analysis was used to describe the frequency distribution of the variables studied, which were then presented in table form and analyzed descriptively.

Data processing and analysis were carried out with the assistance of the computerized SPSS version 16 program to obtain research results that were more systematic and easier to understand (Notoatmodjo, 2010).

4. Results and Discussion

The results of the study conducted on children aged ≤ 1 year who had received BCG immunization at Posyandu within the working area of Raja Basa Indah Public Health Center, Bandar Lampung City, in 2013, based on primary data, obtained a sample of 88 children who met the inclusion criteria. Table 1 presents the frequency distribution of BCG scars in BCG immunization.

Table 1. Frequency Distribution of BCG Scars in Children Aged ≤ 1 Year.

No	Children Who Had Received BCG Immunization	Total	Percentage
1	Developed BCG Scar	67	76.1%
2	Did Not Develop BCG Scar	21	23.9%
	Total	88	100%

The results of this study are consistent with the theory proposed by I.G.N. Ranuh et al. in *Pedoman Imunisasi di Indonesia* 4th edition, which states that the sign of successful BCG immunization is indicated by the appearance of a small lump at the injection site that subsequently develops into a scar or scar tissue resembling a mosquito bite (Ranuh et al., 2011). BCG scars generally begin to appear at the earliest one month and at the latest three months after immunization is administered (Atikah Poerwati et al., 2010). Based on the results of the study conducted at Posyandu within the working area of Raja Basa Indah Public Health Center, Bandar Lampung City, most children who received BCG immunization from January to December 2013 experienced BCG scar formation. Of the 88 children studied, more than 10 children were found not to experience scar formation after BCG immunization injection.

The absence of BCG scars in several respondents was likely influenced by several factors, such as improper injection technique, inappropriate vaccine dosage, and inadequate vaccine quality. Injection techniques performed too deeply and not in accordance with WHO recommendations, namely intradermal injection in the upper right arm in the Musculus deltoideus area at an angle of approximately 15 degrees, may cause the vaccine not to function optimally, resulting in the absence of scar formation (Ranuh et al., 2011). In addition, inappropriate vaccine dosage, such as exceeding 0.05 ml in infants younger than one month or 0.1 ml in children older than one month, may also affect BCG scar formation (Atikah Poerwati et al., 2010). Another influencing factor is vaccine quality and the vaccine storage process. Reconstituted vaccines should preferably be used within no more than three hours to maintain their quality (Kementerian Kesehatan Republik Indonesia, 2011). Although the scar does not appear, BCG immunization does not need to be repeated because antibodies against tuberculosis bacteria have actually been formed, albeit at lower levels (GERDUNAS-TBC, 2011).

A study conducted by Pizzo and Wilfert in 2011 stated that the effectiveness of the BCG vaccine ranges from 70–80% in protecting children from tuberculosis infection. The study explained that children who had received BCG immunization possessed protection against the spread of tuberculosis bacteria, although it did not specifically explain the relationship between BCG immunization administration and the formation of BCG scars.

Another study conducted by Erni Murniasih in 2013 regarding the relationship between BCG immunization administration and the incidence of pulmonary TB in children demonstrated that BCG immunization can reduce the risk of pulmonary tuberculosis in children. This occurs because the immunocompetent cells of the infant's body have already formed since birth, so earlier administration of BCG immunization will induce a more rapid cellular immune response (Aziz Alimul Hidayat, 2008).

The immune response assists the body in combating tuberculosis infection so that the risk of pulmonary TB can be reduced from an early age (Departemen Kesehatan Republik Indonesia, 2013). However, the study placed greater emphasis on the relationship between BCG immunization and the incidence of pulmonary TB and did not discuss the formation of BCG scars after immunization.

According to Briassoulis's study in 2010, not all children who receive BCG immunization experience BCG scar formation. This condition indicates that BCG immunization does not entirely protect children from pulmonary tuberculosis infection.

One possible cause is that children may already have been infected with tuberculosis bacteria before receiving BCG vaccination, particularly in children who had previously shown positive Mantoux test results but were still administered the BCG vaccine (Roth, 2010). Nevertheless, BCG vaccination remains recognized as capable of preventing severe forms of tuberculosis in children, such as miliary tuberculosis and tuberculous meningitis, which may cause death (GERDUNAS-TBC, 2011).

Research conducted by Livana in 2011 also explained that children who had received BCG immunization and possessed BCG scars could still develop pulmonary tuberculosis. This condition may occur because the child had already been infected with tuberculosis bacteria before immunization was administered or because immunization was conducted at an age older than three months without a prior tuberculin test (Livana, 2011). Such conditions cause children to remain at risk of developing tuberculosis despite having received BCG immunization.

To date, research regarding the description of BCG scars in BCG immunization recorded in the KMS of one-year-old children at Posyandu within the working area of Raja Basa Indah Public Health Center, Bandar Lampung City, in 2013 has not been extensively conducted; therefore, this study may be considered a preliminary study. The researcher recognizes several limitations within this study, particularly the difficulty in obtaining previous studies discussing the percentage of children who experienced BCG scar formation and those who did not develop scars after immunization (Mieke Fandri Yunita, 2011). In addition, the limited duration of the study resulted in this research only describing the occurrence or absence of BCG scars without further investigating the duration of scar formation following immunization administration (Soekidjo Notoatmodjo, 2010; Sugiyono, 2005).

Distribution and Clinical Characteristics of BCG Scar Formation in Infants

The results of this study demonstrated that the majority of children aged ≤ 1 year who received BCG immunization at Posyandu within the working area of Raja Basa Indah Public Health Center developed BCG scars following immunization. From a total of 88 children who met the inclusion criteria, 67 children or 76.1% experienced BCG scar formation, while 21 children or 23.9% did not develop scars after immunization. These findings indicate that most BCG immunization procedures administered in the study area successfully stimulated an immunological response characterized by the appearance of scar tissue at the injection site. The presence of BCG scars has long been recognized as one of the clinical indicators reflecting a successful post-vaccination immune response against Mycobacterium tuberculosis infection. Similar findings were reported by Renata Mayangsari et al. (2016), who explained that the appearance of BCG scars is closely associated with the formation of cellular immune responses, particularly interferon-γ activity, which plays a major role in immunity against mycobacterial infections.

The relatively high proportion of scar formation in this study reflects the effectiveness of immunization services implemented at primary healthcare facilities within the Rajabasa Indah area. The achievement of adequate immunization coverage cannot be separated from the role of healthcare workers, Posyandu cadres, and family participation in supporting childhood immunization programs. Sinuhaji and Sembiring (2024) emphasized that evaluating the effectiveness of community health programs significantly contributes to improving BCG immunization coverage among infants aged 0–2 months. Furthermore, community-based health interventions are more likely to succeed when healthcare services are integrated with educational and preventive strategies targeting parents and caregivers.

This condition suggests that successful BCG immunization programs require not only vaccine availability but also effective communication and continuous health promotion activities within the community setting. The emergence of BCG scars after immunization represents a normal physiological process resulting from localized immune reactions occurring gradually after vaccine administration. Following intradermal injection, a small reddish swelling generally develops at the injection site and subsequently progresses into a pustule before healing and leaving scar tissue. According to Prihartini (2017), many mothers initially perceive the appearance of scars or ulcers after BCG immunization as an adverse effect, although medically the condition reflects a normal immunological response.

Misinterpretation regarding the post-immunization reaction may influence maternal attitudes toward subsequent immunization schedules and overall vaccine compliance. Therefore, adequate counseling regarding the normal stages of scar formation after BCG vaccination remains essential to prevent misconceptions and unnecessary anxiety among parents.

The findings of this study also demonstrated that nearly one-fourth of immunized children did not develop BCG scars despite having received the vaccine. This condition may be associated with technical factors during vaccine administration, including injection depth, inappropriate dosage, or reduced vaccine potency resulting from improper storage procedures. Ranuh et al. (2011) explained that BCG immunization must be administered intradermally in the upper arm region with precise injection techniques to stimulate optimal local immune responses. Failure to follow standardized immunization procedures may reduce vaccine effectiveness and consequently inhibit scar formation. In addition, Kementerian Kesehatan Republik Indonesia (2011) emphasized that reconstituted vaccines should be utilized within a limited period to maintain their biological stability and immunogenic quality.

Another important factor influencing BCG scar formation is the immunological condition of the child at the time of vaccination. Infants with low nutritional status or weakened immune systems may exhibit suboptimal immune responses following BCG administration, thereby affecting scar development. Sari (2021) reported that nutritional problems among children in the Raja Basa Indah area, including cases of underweight status below the red line indicator, remain a significant concern in child health management. Malnutrition during infancy may impair immune system maturation and reduce the body's ability to respond effectively to immunization stimuli. Consequently, nutritional improvement programs remain crucial components in supporting the success of immunization outcomes and reducing susceptibility to infectious diseases among children.

Breastfeeding practices and infant feeding behaviors may also contribute to the immunological response observed after BCG vaccination. Exclusive breastfeeding provides immunological protection through maternal antibodies and bioactive compounds that support infant immune development during early life. Yulia Novika (2019) highlighted that breastfeeding practices among mothers in the Rajabasa area significantly influence infant health resilience and immune adaptation during the first months of life. Similarly, Juherman et al. (2022) found that inappropriate infant feeding practices may compromise child nutritional status and immune competence. Therefore, optimal breastfeeding and complementary feeding practices should be regarded as supportive factors that may enhance vaccine responsiveness and improve overall child health outcomes.

The role of family empowerment and community participation also constitutes an important determinant in improving childhood health and immunization compliance. Fatonah et al. (2025) emphasized that empowering community health cadres and families contributes significantly to improving maternal awareness regarding child nutrition, disease prevention, and immunization adherence within the Rajabasa Jaya area. Strengthening community-based healthcare initiatives may increase parental understanding regarding the importance of early immunization and the significance of post-immunization responses such as scar formation. Community empowerment programs also facilitate better communication between healthcare providers and parents regarding childhood infectious disease prevention. Consequently, the sustainability of preventive healthcare programs requires active collaboration between healthcare institutions, families, and community organizations.

Although scar formation is generally interpreted as evidence of successful BCG immunization, the absence of scars does not necessarily indicate immunization failure. Several studies have demonstrated that protective immunity against tuberculosis may still develop despite the absence of visible scar tissue. Renata Mayangsari et al. (2016) explained that cellular immune activity, including interferon-γ production, may remain detectable in children without obvious scar formation following BCG vaccination. This finding indicates that immunological protection cannot solely be assessed based on the visual appearance of scars on the skin surface. Therefore, clinical evaluation of immunization outcomes should consider broader immunological mechanisms rather than relying exclusively on external physical indicators.

Immunization Effectiveness and Tuberculosis Prevention in Children

The findings of this study further support the important role of BCG immunization in reducing the risk of tuberculosis infection among children, particularly during early childhood when the immune system remains immature and highly vulnerable to infectious diseases. Tuberculosis continues to be one of the major public health concerns in developing countries due to its high transmission rate and its potential to cause severe complications in pediatric populations. Febrian (2015) explained that childhood pulmonary tuberculosis is strongly associated with inadequate immunization status, poor nutritional conditions, and prolonged exposure to infected household members. Early administration of BCG vaccination therefore becomes an essential preventive strategy in reducing the incidence of severe tuberculosis manifestations among children. The relatively high percentage of scar formation observed in this study may indicate that the majority of vaccinated children developed sufficient immunological responses capable of contributing to tuberculosis prevention.

The protective mechanism induced by BCG vaccination primarily involves stimulation of the cellular immune response, particularly T-lymphocyte activation against Mycobacterium tuberculosis antigens. Unlike humoral immunity, cellular immunity plays a dominant role in controlling intracellular pathogens such as tuberculosis bacteria. Renata Mayangsari et al. (2016) emphasized that interferon-γ activity following BCG vaccination reflects the activation of protective immune mechanisms against mycobacterial infections. Adequate immune activation following immunization contributes not only to scar formation but also to long-term protection against severe tuberculosis complications. Consequently, the presence of scars may indirectly reflect the successful activation of immunological pathways essential for childhood tuberculosis prevention.

Despite the recognized effectiveness of BCG immunization, several children may still develop tuberculosis even after vaccination. This phenomenon may occur because BCG vaccines do not provide absolute protection against all forms of tuberculosis infection. Triharinni and Isvandiari (2014) reported that children with a history of close contact with tuberculosis patients remain vulnerable to infection despite prior immunization, particularly when environmental exposure persists over prolonged periods. Positive tuberculin test results among previously immunized children may therefore indicate prior bacterial exposure rather than vaccine failure. These findings suggest that BCG immunization should be integrated with broader tuberculosis control measures, including household contact screening and environmental health interventions.

Environmental and socioeconomic conditions also contribute significantly to the transmission dynamics of tuberculosis among children. Overcrowded housing conditions, poor ventilation, inadequate sanitation, and limited healthcare access increase the risk of Mycobacterium tuberculosis transmission within communities. Jumiati et al. (2021) identified several environmental risk factors associated with pulmonary tuberculosis incidence, including poor residential conditions and insufficient public health awareness. Children living in densely populated urban environments therefore remain at greater risk of tuberculosis exposure despite immunization efforts. Consequently, tuberculosis prevention strategies should incorporate environmental improvements alongside vaccination programs to maximize public health outcomes. The timing of BCG administration also plays an important role in determining vaccine effectiveness and immunological response development. Early immunization during infancy allows the immature immune system to develop protective mechanisms before significant exposure to tuberculosis bacteria occurs.

Sinuhaji and Sembiring (2024) highlighted that improving BCG immunization coverage among infants aged 0–2 months remains a critical strategy in strengthening early childhood disease prevention programs. Delayed immunization may reduce vaccine effectiveness because infants may already have been exposed to infectious agents prior to vaccination. Therefore, ensuring timely vaccination according to national immunization schedules remains essential for achieving optimal protective benefits.

Maternal knowledge and healthcare-seeking behavior substantially influence childhood immunization compliance and disease prevention outcomes. Parents who possess adequate knowledge regarding the benefits and expected reactions of BCG vaccination are generally more likely to complete recommended immunization schedules for their children.

Rizka et al. (2026) demonstrated that family-centered health education programs significantly improve parental understanding regarding the benefits of BCG immunization among infants aged 0–12 months. Increased parental awareness contributes positively to immunization adherence and reduces vaccine hesitancy associated with misconceptions regarding post-vaccination scar formation. Consequently, educational interventions remain an integral component of successful immunization and tuberculosis prevention programs.

In addition to immunization status, nutritional adequacy and infant feeding patterns also influence susceptibility to tuberculosis infection. Children with poor nutritional conditions often experience weakened immune defenses that increase vulnerability to infectious diseases, including tuberculosis. Juherman et al. (2022) emphasized that inappropriate feeding practices during infancy may compromise child health and immune system development within communities served by Rajabasa Public Health Center. Likewise, Yulia Novika (2019) noted that inadequate breastfeeding practices may reduce the immunological benefits necessary for optimal infant growth and disease resistance. These findings indicate that childhood tuberculosis prevention requires integrated nutritional and immunological support beginning from early infancy.

The present study may therefore contribute important preliminary evidence regarding the distribution of BCG scar formation among children within the Raja Basa Indah Public Health Center area and its implications for immunization effectiveness. Although the study was limited to descriptive observations regarding the occurrence and absence of scars, the findings remain relevant for understanding post-immunization responses within community healthcare settings. The limited availability of previous studies specifically discussing BCG scar prevalence among Indonesian children further highlights the importance of continued research in this field. Future studies are recommended to investigate the relationship between scar formation, immunological biomarkers, nutritional conditions, and long-term tuberculosis protection outcomes in children. Through more comprehensive investigations, immunization policies and tuberculosis prevention programs may be further optimized to improve child health outcomes at both local and national levels.

Additional evidence from international cohort studies further strengthens the understanding that BCG scar formation is closely associated with vaccine effectiveness and broader child health outcomes. Funch et al. (2018) reported that the development of BCG scars among children in rural Guinea-Bissau was influenced by multiple determinants, including vaccination technique, nutritional condition, and the timing of immunization administration, all of which contributed to variations in post-vaccination immune responses. Similarly, Jason et al. (2002) demonstrated that children who developed BCG scars showed stronger clinical and immunological responses compared to children without visible scarification, suggesting that scar formation may reflect more robust activation of protective cellular immunity. These findings are particularly relevant to the present study because they support the observation that the majority of children who developed scars after BCG immunization likely experienced adequate immunological stimulation following vaccination. Furthermore, Dommergues et al. (2009) explained that local skin reactions, including ulceration and scar development, represent common post-vaccination phenomena associated with the body's adaptive immune response, although the intensity and duration of these reactions may vary depending on vaccine strain, administration technique, and individual immunological characteristics.

In addition to its role as an indicator of successful immunological response, BCG scar formation has also been associated with broader protective effects on child survival and morbidity outcomes. Roth et al. (2005) found that children with visible BCG scars exhibited better childhood survival rates compared to children without scars, indicating that scar formation may correlate with stronger nonspecific protective immune mechanisms beyond tuberculosis prevention alone. Likewise, Storgaard et al. (2015) reported that the development of BCG scars was associated with lower morbidity and mortality rates among children in rural Guinea-Bissau, emphasizing the potential importance of scarification as a marker of enhanced immunological resilience during early childhood. These international findings provide additional scientific support for the results of the present study, particularly regarding the significance of scar formation as an observable indicator of vaccine-induced immune activation.

Consequently, monitoring BCG scar development may not only assist healthcare providers in evaluating immunization success but may also contribute to identifying children who potentially require closer immunological and clinical follow-up after vaccination.

5. Conclusion

Based on the results of the study regarding the description of BCG scars in 1-year-old children recorded in the KMS at Posyandu within the working area of Raja Basa Indah Public Health Center, Bandar Lampung City, in 2013, the findings revealed that the majority of children who had received BCG immunization experienced the development of BCG scars, amounting to 76.1%. Meanwhile, children who did not experience the development of BCG scars accounted for 23.9%. These results indicate that the majority of BCG immunization administrations had produced an immune response characterized by the formation of scars at the injection site.

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