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Comparison of Estimated Number of Stunting Sufferers in Indonesia Using Stratified and Simple Random Sampling

Muhammad Zulfadhli [1*], Aulia Rahmah Ramadlana [1], Askin Nur Habibah [1], and Shinta Istibsyaroh Umami [1]

[1]Department of Statistics, Institut Teknologi Sepuluh Nopember, Surabaya 60111, Indonesia

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ABSTRACT

Stunting is one of the public health problems that is still high in Indonesia. This problem has a long-term impact on the quality of human resources. Therefore, accurate measurement and estimation of the number of stunting sufferers is very important as a basis for policy making. This study aims to estimate the number of stunting sufferers in Indonesia using two statistical approaches, namely Stratified Random Sampling and Simple Random Sampling. With a population of 510 districts/cities, it is classified into four strata based on the number of stunting cases. Samples were randomly selected and calculated at the estimated point and interval of the estimate. The results showed that the Stratified Random Sampling method provided a smaller estimation variance than Simple Random Sampling. These findings suggest that the stratification approach is more efficient for data with high heterogeneity.

Keywords: *Estimation, Simple Random Sampling, Stratified Random Sampling, Stunting, Variance.*

***Corresponding Author:** muhammadzulfadhli23@gmail.com*

1. Introduction

Stunting is a condition of impaired growth and development in children under five years of age caused by chronic malnutrition and recurrent infections, particularly during the first 1,000 days of life. According to the World Health Organization (WHO), a child is classified as stunted if their height-for-age Z-score (HAZ) is below −2 standard deviations (−2 SD) from the WHO Child Growth Standards, and severely stunted if the HAZ is below −3 SD. Globally, the prevalence of stunting has decreased from around 26.3% in 2012 to 22.3% in 2022, but the long-term negative effects on cognitive development, work productivity, and the national economy remain a serious problem [1]. In Indonesia, the prevalence of stunting is also relatively high despite showing a downward trend in recent years. For example, the 2022 national nutrition survey recorded a national stunting rate of around 21.6% [2]. High stunting is a source of economic losses and has the potential to cause losses of Rp 15,062–67,780 billion (around 0.89–3.99% of total GDP) [3].

Accurate determination of the prevalence and number of stunting sufferers is critical to designing data-driven policy interventions at the national and local levels. Studies show that sanitation factors, access to drinking water, and maternal education significantly affect the risk of stunting of Indonesian children [4]. The dominant determinants of stunting have been studied by experts including maternal education, low birth weight, economic status, and exclusive breastfeeding [5]. Several studies also state that the prevalence of stunting in Southeast Asia, including Indonesia is influenced by socio-economic and sanitation determinants [6].

Methodologically, large surveys such as the National Socio-Economic Survey (SUSENAS) or the Indonesian Family Life Survey (IFLS-5) use a stratified multistage sampling design to ensure national representativeness while managing sampling costs and efficiency [7]. This design often combines stratification based on region, urban–rural, and demographic characteristics. The general literature on stratified sampling explains its advantages, especially in reducing sampling errors when strata are homogeneous and population distributions are diverse [8].

In the context of Indonesia, which has a heterogeneous population and an uneven distribution of stunting between regions, the stratification approach is more efficient than conventional simple random sampling (SRS). Stratification can significantly lower the estimated variance if strata are selected based on relevant variables and internal homogeneity. In fact, the estimated variance of SRS is about 1.3× the stratified variant when appropriate strata are used [9]. A concrete illustration of this heterogeneity can be seen in provincial stunting prevalence: provinces such as Papua Tengah and Nusa Tenggara Timur (NTT) record some of the highest stunting rates in the country, around 39% and 37–38%, respectively while provinces like Bali have some of the lowest, around 7–9% prevalence of stunting among children under five. However, stratification can sometimes worsen estimates if strata are not suitable or the allocation is not optimal [10]. Studies in the field of social surveys in Indonesia have also developed stratification techniques that consider geographical and welfare dimensions, such as in the context of remote areas in Papua, which have succeeded in finding efficient sampling scenarios with low variance and minimal cost [11].

This study aims to compare two sampling approaches Stratified Random Sampling (STRS) and Simple Random Sampling (SRS) in estimating the total number of stunting cases in Indonesia, with a particular focus on the efficiency of each method as reflected in the magnitude of the estimation variance, the margin of error, and the representativeness of the estimated results. The central research question guiding this study is: In what ways do SRS and STRS differ with respect to variance, margin of error, and estimation accuracy for the total number of stunting cases in Indonesia? Previous studies in survey methodology and public health have shown that stratified sampling generally yields lower variance and smaller margins of error than SRS when applied to heterogeneous populations, and Indonesia's wide regional disparities in stunting prevalence, ranging from very high levels in provinces such as East Nusa Tenggara to much lower levels in provinces such as Bali, underscore the relevance of this approach.

In contrast, Stratified Random Sampling (STRS) offers the advantage of explicitly incorporating population heterogeneity into the sampling design by dividing the population into relatively homogeneous strata before sampling. This approach typically leads to lower estimation variance and smaller margins of error, especially when the strata are constructed using variables strongly correlated with the study outcome, such as regional stunting burden. STRS also improves representativeness, ensuring that key subpopulations or regions with very high or very low stunting prevalence are adequately reflected in the sample. As a result, STRS is particularly well suited for national-level health studies in countries like Indonesia, where substantial regional disparities exist.

However, existing stunting-related research in Indonesia has largely focused on prevalence, determinants, and trends, with limited attention to a direct methodological comparison of sampling designs. The novelty of this study lies in its explicit and quantitative comparison of STRS and SRS for estimating national stunting totals, providing empirical evidence on variance reduction and estimation efficiency that can inform the design of future large-scale nutrition and health surveys in Indonesia. From a public policy and public health survey perspective, the use of STRS allows for the grouping of populations based on relevant strata such as provincial [12], urban/rural [13], or economic level [14]. This improves the accuracy of estimates and allows for sub-population analysis while keeping survey costs under control. Stratification supports high-efficiency sub-population-specific estimation and representativeness. [15].

2. Method Details

2.1. Strata Grouping by Quartile

All population units (districts/cities) are grouped into four strata based on the quartile of the number of people stunted. The formation of these strata is based on the principle that units with similar characteristics will be grouped together, to reduce variance in strata and improve the efficiency of total estimation [16]. Stratification based on additional variables that are highly correlated with the main variable (in this case, the number of stunting cases) can significantly improve the accuracy of the estimate by decreasing the resulting sampling variance.

In addition, the use of quartile-based stratification ensures that each stratum represents a distinct level of stunting burden, ranging from low to high, which helps capture the underlying heterogeneity across districts/cities. By aligning strata boundaries with the empirical distribution of stunting cases, this approach enhances within-stratum homogeneity and strengthens the ability of the sampling design to produce more precise and representative estimates. Consequently, the stratified estimator is expected to yield a smaller variance and narrower margin of error compared with an unstratified approach, particularly in populations with pronounced regional disparities such as Indonesia.

2.2. Stratified Random Sampling

Stratified Random Sampling (SRS) is a sampling technique in which the population is divided into exclusive subgroups (strata), and samples are taken randomly from each stratum independently [17]. In this study, strata divisions were carried out based on the quartile number of stunting cases, resulting in four strata: low, medium, high, and very high. This approach ensures proportional representation of strata in the sample, which is important considering the highly variable distribution of stunting between regions in Indonesia [18].

By using quartile stratification, variation between strata is maximized while variance within strata is minimized, thereby increasing the accuracy of estimating total stunting at the national level [13]. Random sampling is carried out independently in each stratum, and the number of samples in each stratum is allocated proportionally to the size of the strata (proportional allocation).[6].

$$n_h = n \times \left({N_h}/{N} \right) \tag{1}$$

Simple proportional allocation is applied when there is no adequate strata variance information and produces a representative sample without the need for additional weighting. This strategy is effective for ensuring the proportion of the sample reflects the population distribution of each stratum. In the case of strata that are relatively internally homogeneous but heterogeneous between strata-especially the distribution of stunting between districts/cities-this method theoretically reduces estimation errors and increases accuracy compared to Simple Random Sampling [6].

2.3. Simple Random Sampling (SRS)

Simple Random Sampling (SRS) is used both as part of the process of selecting sample units within strata and as a comparison or baseline for stratification results [17]. In this context, each district/city unit has an equal opportunity to be selected regardless of strata. This method serves as a control in evaluating the efficiency of the stratification method. The main advantage of SRS is its ease of implementation and neutrality to the population structure. However, this method can be less efficient if the population is very heterogeneous such as the distribution of stunting cases that varies between regions in Indonesia [18].

In non-homogeneous populations, SRS has the potential to produce estimates with high variance due to large internal variations in the sample [19]. Comparative sampling studies in Nigeria show that Stratified Random Sampling is more efficient than SRS based on the minimum variance criteria [19]. In addition, SRS requires a complete population frame which is often difficult to obtain for broad coverage [18] and can be biased if small subgroups are under-represented in the sample [20].

2.4. Sample Size Determination

The sample size in this study was determined using a total population estimation formula adjusted for the Stratified Random Sampling (STRS) technique. This determination takes into account a specific margin of error (error tolerance) to produce a precise estimate. The formula used refers to the formula for estimating the total sample size as follows:

$$n = \frac{\sum_{h=1}^{L} \frac{N_h^2 \sigma_h^2}{W_h}}{N^2 D + \sum_{h=1}^{L} N_h \sigma_h^2} \tag{2}$$

where: W_h = weights for strata to H, the value depends on the allocation of the sample to be used

In this context, a proportional allocation strategy is used, namely the allocation of sample size in each stratum according to the proportion of the population size of the strata. So. The use of this formula allows efficient calculation of sample sizes in stratification, taking into account the heterogeneity of data between strata and ensuring a balanced representation. This formulation is recommended in a variety of survey statistical literature because it can minimize the total variance of population estimates $W_h = N_h / N$ [21][22].

3. Results and Discussion

3.1. Stratification Method

The total number of stunting cases in Indonesia was 19,477,434 cases, based on data from the 2024 Indonesian National Nutrition Status Survey conducted by the Ministry of Health of the Republic of Indonesia. The territory of Indonesia is divided into 38 provinces and 510 cities/districts. Data on the number of stunting sufferers per district/city. Data in 510 city districts as a sampling frame, then districts/cities are classified into 4 strata based on the number of cases, namely: Very Low, Low, High, and Very High. Using Quartiles, strata 1 is in the case range <94119411, strata 2 is in the case range 94119411 < x <18941189411, strata 3 is in the case range 18941189411 < x < 39265, and strata 4 is in the case range > 39265. The population of each stratum was obtained, where the strata 1 population was 127 regencies/cities, strata 2 population was 128 regencies/cities, strata 3 population was 128 regencies/cities, and strata 4 population was 127 regencies/cities.

3.2. Parameter Estimation Using the Stratified Random Sampling Method

3.2.1. Determining the Sample Size to Estimate the Total ($\hat{Y}_{st}$) Stunting Sufferers in Indonesia

In this study, a study will be designed to estimate the total number of stunted babies in Indonesia with a population (N) of 510, *the bound of error* (B) of 3,850,000 and a α value of 0.05. So, the size of the sample size "n" to estimate the total can be calculated using the formula in equation 2, where $(\hat{\tau})$:

$$D = \left(\frac{B}{N z_{1-\alpha/2}}\right)^2 = \left(\frac{3,850,000}{510 \times 1.96}\right)^2 = 14834365,12$$

Table 1. Sample Size Calculation Results

Stratum	N_h	N_h^2	σ_h^2	W_h	$N_h^2\sigma_h^2 / W_h$	$N_h\sigma_h^2$
1	127	16129	4860072.785	0.24902	3.14787×10^{11}	617229243.7
2	128	16384	7286296.063	0.25098	4.79395×10^{11}	939989564.5
3	128	16384	30975978.54	0.25098	2.02211×10^{12}	3964925253
4	127	16129	16199277430	0.24902	1.04923×10^{15}	2.05731×10^{12}
Sum					1.05204×10^{15}	2.06283×10^{12}

$$
\begin{aligned}
n &= \frac{\sum_{h=1}^{4} \frac{N_h^2 \sigma_h^2}{W_h}}{N^2 D + \sum_{h=1}^{4} N_h \sigma_h^2} \\
&= \frac{1.05204 \times 10^{15}}{\left(510^2 \times 14834365.12\right) + 2.06283 \times 10^{12}} \\
&= 177.6725718 \\
&\cong 178
\end{aligned}
$$

Thus, the sample size to estimate the total number of stunted babies using *the stratified random sampling* method is 178 samples. Furthermore, in determining the proportional allocation size of the sample to strata, it can be calculated using the following formula [21]:

$$
n_h = n \frac{N_h}{\sum_{h=1}^{L} N_h} = n \times \left({N_h}/{N} \right) \tag{3}
$$

Thus, the proportional allocation size of the sample to each stratum was obtained

$$
\begin{aligned}
n_1 &= 178 \times \frac{127}{510} \cong 44 \\
n_2 &= 178 \times \frac{128}{510} \cong 45 \\
n_3 &= 178 \times \frac{128}{510} \cong 45 \\
n_4 &= 178 \times \frac{127}{510} \cong 44
\end{aligned}
$$

Thus, the proportional allocation size of samples in strata 1 was obtained as many as 44 samples, strata 2 as many as 45 samples, strata 3 as many as 45 samples, and strata 4 as many as 44 samples. Furthermore, using the help of Ms. Excel, simple random sampling was carried out from each stratum. Where, the randomization process provides the same opportunity for each sampling unit to be selected as a research sample in each stratum. After sample selection using the SRS method, data per strata was generated.

3.2.2. Total Estimate ($\hat{Y}_{st}$) Stunting Sufferers in Indonesia

To obtain an accurate overview of the prevalence of stunting in Indonesia, it is essential to estimate the total number of affected individuals based on representative sample data. Using a stratified random sampling approach allows for better precision by accounting for population heterogeneity across regions and demographic groups. The following section presents the point estimation results, which provide an unbiased estimate of the total number of stunting sufferers in the population. Table 2 summarizes the outcomes of the stratified random sampling point estimation procedure.

Table 2. Stratified Random Sampling Point Estimation Results

Stratum	N_h	n_h	$\bar{y}_h$	$N_h \bar{y}_h$
1	127	44	5251.068	666885.7
2	128	45	14069.07	1800841
3	128	45	27403.16	3507604
4	127	44	90405.43	11481490
		$\sum_{h=1}^{4}$		17456820

so, $\hat{Y}_{st} = \sum_{h=1}^{4} N_h y_h = 17456820$

Based on the calculation of the estimated point, it can be concluded that the estimated number of stunting sufferers in Indonesia is 17,456,820 children.

Table 3. Continued Stratified Random Sampling Point Estimation Results

Stratum	N_h	N_h^2	$\frac{N_h - n_h}{N_h - 1}$	σ_h^2 / n_h	$N_h^2 \left(\frac{N_h - n_h}{N_h - 1}\right) \sigma_h^2 / n_h$
1	127	16129	0.658730159	109586.4658	1164318801
2	128	16384	0.653543307	161917.6903	1733758530
3	128	16384	0.653543307	682977.3045	7313084355
4	127	16129	0.658730159	365266456	3.88083×10^{12}
Number					3.89104×10^{12}

The value of the variance of the total estimate for the stratified random sampling method can be calculated with the following equation [21].

$$V\left(\hat{Y}_{st}\right) = \sum_{h=1}^{4} N_h^2 \left(\frac{N_h - n_h}{N_h - 1}\right) \frac{\sigma_h^2}{n_h} = 3.89104 \times 10^{12} \tag{4}$$

So that the variance value of the total estimate for the *stratified random* sampling method is obtained as $3{,}89104 \times 10^{12}$. The estimated interval, also known as the confidence interval, represents the range within which the true population parameter is expected to lie with a certain level of confidence, typically 95%. Unlike point estimation, which provides a single best estimate, the interval estimation accounts for sampling variability and uncertainty. Therefore, it offers a more reliable reflection of the precision of the estimate. A narrower interval indicates higher precision, while a wider interval suggests greater uncertainty in the estimation results.

$$P\left(\hat{Y}_{st} - Z_{1-\alpha/2}\sqrt{\frac{V\left(\hat{Y}_{st}\right)}{n}} \le Y_{st} \le \hat{Y}_{st} + Z_{1-\alpha/2}\sqrt{\frac{V\left(\hat{Y}_{st}\right)}{n}}\right) = 1 - \alpha \tag{5}$$

By using equation 5, the results of the interval estimation are as follows:

$$P\left(1745682 - 1.96\sqrt{\frac{3.89104 \times 10^{12}}{178}} \le Y_{st} \le 1745682 + 1.96\sqrt{\frac{3.89104 \times 10^{12}}{178}}\right) = 95\%$$

$$P\left(171670322{,}8 \le Y_{st} \le 17746607{,}1\right) = 95\%$$

Based on the calculation of the estimated interval, it can be concluded that the estimated number of stunting sufferers in Indonesia ranges from 17,167,033 to 17,746,608 children.

3.3. Parameter Estimation Using Simple Random Sampling Method

3.3.1. Determining the Sample Size to Estimate the Total ($\hat{Y}$) Stunting Sufferers in Indonesia

The sample size of "*n*" to estimate the total can be calculated using the formula [21]

$$n = \frac{N\sigma^2}{(N-1)D + \sigma^2} \tag{6}$$

where: $D=\left(\frac{B}{N_{Z_{1-\alpha/2}}}\right)^2$ (7)

Thus, the sample size estimates the total number of stunted babies with N = 510, B = 3850000, and α = 0.05. So $\sigma^2 = 5623092645,495$.

$$D=\left(\frac{3,850,000}{510\times 1.96}\right)^2 = 14834365.12 \quad (8)$$

$$\begin{aligned} n &= \frac{(510)\times(5612066973.641)}{(510-1)(14834365.12)\times(5612066973.641)} \\ &= 217.688 \approx 218 \end{aligned} \quad (9)$$

so the sample size was obtained using *simple random sampling* as many as 218 samples. Furthermore, using the help of Ms. Excel, random sampling was carried out, so that the samples taken were produced.

3.3.2. Total Estimate ($\hat{Y}$) Stunting Sufferers in Indonesia

1) Point Estimation

The estimated total value of stunted babies in Indonesia using *the Simple Random Sampling method* can be calculated with the following equation [22].

$$\begin{aligned} \hat{Y} &= N\bar{y} = N\frac{\sum_{i=1}^{n} y_i}{n} \\ &= 510\times 35200,854 \\ &= 17952435,479 \end{aligned} \quad (10)$$

So that an estimate of the total number of stunted babies in Indonesia using *the simple random sampling method* was obtained of 17952435,479 children. The value of the variance from the total estimate for *the simple random sampling method* can be calculated with the following equation [21].

$$V(\hat{Y}) = \frac{N^2 S^2}{n}\left(\frac{N-n}{N}\right) \quad (11)$$

$$\begin{aligned} V(\hat{Y}) &= \frac{(510^2)(5623092645,495^2)}{218}\left(\frac{510-218}{510}\right) \\ &= 8.98639\times 10^{12} \end{aligned}$$

So that the value of variance from the total estimate for *the simple random sampling method* was obtained of 8.98639 x 1012

2) Estimated Interval

The estimated interval for *the simple random sampling method* can be calculated with the following equation [22].

$$P\left(\hat{Y} - Z_{1-\alpha/2}\sqrt{\frac{V(\hat{Y}_{st})}{n}} \le Y \le \hat{Y} + Z_{1-\alpha/2}\sqrt{\frac{V(\hat{Y}_{st})}{n}}\right) = 1-\alpha \quad (12)$$

$$P\left(17952435,479 - 1.96\sqrt{\frac{8.98639\times 10^{12}}{218}} \le Y_{st} \le 17952435,479 + 1.96\sqrt{\frac{8.98639\times 10^{12}}{218}}\right) = 95\%$$

$$P(17554492,77 \leq Y \leq 18350378,19) = 95\%$$

Based on the calculation of the estimated interval, it can be concluded that the estimated number of stunting sufferers in Indonesia ranges from 17,554,493 -18,350,379 children.

3.4. Comparing Estimation Results from Stratified Random Sampling and Simple Random Sampling Methods

The comparison of the results of the total estimate of stunting sufferers in Indonesia is relatively different, so to get the best estimate, it is necessary to compare the variance of the total estimates for *the Stratified Random Sampling* (STRA) and *Simple Random Sampling* (SRS) methods. The results of the variance estimate can be seen as follows.

Table 4. Value of Variance from Total Estimate

$V(\hat{Y}_{st})$	3.89104×10^{12}
$V(\hat{Y})$	8.98639×10^{12}

Therefore, it was concluded that the *Stratified Random Sampling* (STRA) method is better to estimate the total number of stunting sufferers because it has a smaller variance.

4. Conclusion

Based on the estimated results, it was obtained that using Stratified Random Sampling, the estimated number of stunting sufferers in Indonesia is 17,456,820 children, with a 95% confidence interval between 17,167,033 to 17,746,608 children. The total estimated variance obtained was 3.89×10^{12}, indicating a high level of accuracy. Meanwhile, using Simple Random Sampling, the estimated number of stunting sufferers is 17,952,435 children, with a 95% confidence interval between 17,554,493 and 18,350,379 children. However, the total estimated variance was larger, at 8.99×10^{12}, which indicates lower accuracy than the stratification method.

The results of the comparison show that Stratified Random Sampling is superior in providing more accurate and efficient estimates. This can be seen from the smaller variance values and the distribution of samples that are more representative of the characteristics of the population, because it considers the variation in the number of stunting cases in each stratum (Very Low, Low, High, and Very High).

Thus, it can be concluded that in the context of a heterogeneous population such as the distribution of stunting in Indonesia, the use of Stratified Random Sampling is highly recommended to produce better estimates than simple random methods.

Limitations

None

Author Contributions Statement

All authors have made significant contributions to this study and meet the authorship criteria based on the CRediT (Contributor Roles Taxonomy) guidelines. The contributions of each author are as follows:

- Muhammad Zulfadhli:
  Conceptualization, Methodology Development, Formal Analysis, Initial Draft Writing
- Aulia Rahmah Ramadlana:
  Data Collection and Curation, Investigation, Visualization, Review and Manuscript Editing
- Askin Nur Habibah:
  Supervision of Manuscripts, Validation, Review and Editing
- Shinta Istibsyaroh Umami:
  Resource Provision, Project Administration

Conflict of Interest Statement

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Data Availability

Data availability does not apply to this paper as no new data were created or analyzed in this study.

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