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Assessing factors influencing noncompliance with mass drug administration for lymphatic filariasis in urban and rural Indonesia

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ABSTRACT

Objective: To study assessed factors associated with mass drug administration (MDA) noncompliance for lymphatic filariasis in urban and rural Indonesian communities.

Methods: A cross-sectional analysis was conducted using a subset of nationally representative data from the 2023 Indonesian Health Survey (Survei Kesehatan Indonesia, SKI). Participants were classified as residing in urban (n=469 549) and rural (n=407 982) and interviewed regarding anti-filarial drugs intake over the past 5 years. Logistic regression models were constructed to identify factors associated with MDA noncompliance.

Results: A total of 877 531 individuals from 284 177 households across 514 districts in 38 provinces were included in the study. Among them, 136 526 (15.56%) took anti-filarial drugs in five years; of these, 27 113 (19.86%) never complied fully, revealing significant urban-rural disparities. In urban areas, noncompliance with MDA was associated with pre-working age group (a*OR* 1.58; 95% *CI* 1.21-2.07) and those with self-reported LF (a*OR* 1.47; 95% *CI* 1.13-1.91). Awareness of health facilities was protective against noncompliance (a*OR* 0.29; 95% *CI* 0.11-0.77). In contrast, rural noncompliance was associated with transportation cost barriers (a*OR* 1.55; 95% *CI* 1.21-1.99), children aged 2-5 years (a*OR* 1.43; 95% *CI* 1.08-1.87), mobile phone ownership (a*OR* 1.40; 95% *CI* 1.12-1.75), and self-reported LF (a*OR* 1.47; 95% *CI* 1.19-1.82).

Conclusions: Distinct demographic, socioeconomic, and accessibility factors influence MDA noncompliance in Indonesia. Targeted behavioral interventions in urban areas and improved communication and access in rural regions are essential for LF elimination.

KEYWORDS: Lymphatic filariasis; Mass drug administration; Compliance; Indonesia

Summary

Question: What factors are associated with noncompliance with mass drug administration for lymphatic filariasis in urban and rural Indonesia.

Findings: In this cross-sectional study using 2023 Indonesian Health Survey data, 877 531 individuals were analyzed, of whom 136 526 had received anti-filarial drugs and 27 113 were noncompliant. Noncompliance showed significant urban-rural differences; in urban areas, it was associated mainly with pre-working age and self-reported lymphatic filariasis, whereas in rural areas, it was associated with transportation cost barriers, young age, mobile phone ownership, and self-reported lymphatic filariasis.

Meaning: Determinants of noncompliance differ between urban and rural settings, indicating that location-specific strategies are needed to improve mass drug administration uptake and support lymphatic filariasis elimination in Indonesia.

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1. Introduction

Lymphatic filariasis (LF), commonly referred to as elephantiasis, is a debilitating mosquito-borne parasitic infection and one of the World Health Organization (WHO) designated neglected tropical diseases. It is caused by filarial nematodes, specifically *Wuchereria bancrofti*, *Brugia malayi*, and *Brugia timori*, which are transmitted to humans through the bites of infected mosquitoes[1]. In addition to onchocerciasis, LF constitutes a major global public health concern, with symptoms including severe swelling of the limbs and genitals that can lead to long-term physical disability and substantial socioeconomic impact[1,2]. These infections are endemic in approximately 73 countries across Asia, Africa, the Western Pacific, and parts of the Caribbean and South America.

In response to the widespread burden of LF, the WHO launched the Global Programme to Eliminate Lymphatic Filariasis (GPELF) in 2000, aiming to interrupt transmission and manage morbidity through a two-pillar strategy: mass drug administration (MDA) and morbidity management and disability prevention (MMDP)[3,4]. While significant progress has been made, with 17 countries declared LF-free, approximately 657 million people still require preventive chemotherapy[5,6]. In light of these ongoing challenges, the WHO has revised its target, setting a new goal to eliminate LF in 80% of endemic countries by 2030[7,8].

Indonesia presents a complex LF epidemiological profile, as all three species of filarial parasites are endemic within its archipelago country. From 2011 to 2021, chronic LF cases were reported in 34 out of 38 provinces, with the highest prevalence observed in Papua, East Nusa Tenggara, and West Papua[9]. Early intervention trials at the village level involving the administration of diethylcarbamazine (DEC) combined with albendazole demonstrated the safety and efficacy of MDA[10,11]. Since then, Indonesia has scaled up MDA through annual and semiannual strategies aligned with the GPELF, aiming to achieve national coverage and eliminate LF transmission [12].

Despite these concerted efforts, Indonesia continues to face numerous global and local challenges in achieving LF elimination. These include the absence of an effective vaccine, the potential for parasite resistance, limited drug uptake, and sociocultural as well as behavioral factors affecting treatment compliance[1,2]. Previous studies have highlighted that individual awareness, perceived susceptibility, trust in healthcare workers, and experiences with side effects significantly influence adherence to MDA[13,14]. In addition, social mobilization, community engagement, and support from local leaders have been shown to positively influence MDA compliance[1], emphasizing the importance of community-centered interventions.

Nonetheless, there remains a significant lack of large-scale, population-based research examining the determinants of MDA compliance for LF in Indonesia. The archipelagic nature of Indonesia, characterized by significant geographical fragmentation, poses inherent structural and logistical barriers to the consistent implementation and achievement of high compliance rates across diverse regions[16]. To address this gap, the present study utilizes data from the 2023 Indonesia National Health Survey (Survey Kesehatan Indonesia, SKI) to investigate sociodemographic and behavioral factors associated with MDA noncompliance in both urban and rural settings. By identifying these determinants, the findings provide robust evidence to support national and local public health authorities in refining and enhancing strategies for LF elimination programs.

2. Methods

2.1. Study sites

Indonesia is an archipelagic and tropical country in Southeast Asia, with a population of over 270 million, occupying an area of approximately 1.9 million square km. The country is administratively divided into 514 districts and 38 provinces, 236 of which are endemic for LF. In accordance with Indonesia National Health Survey (SKI) 2023, the prevalence of LF varies geographically at the district level, with the highest prevalence reported in South Manokwari, Papua, at 11.6% [95% confidence interval (*CI*): 6.0%-21.2%] (Figure 1). Indonesia successfully reduced the number of districts requiring annual preventive drugs to just 17 out of 514 districts in 2023, and the number of people requiring preventive drugs has decreased from 106 million to less than 3 million[2].

2.2. Study design, sampling of participants, and data collection

This study was a secondary analysis of the SKI 2023, a nationwide cross-sectional survey by the Ministry of Health's Health Policy and Development Agency (HPDA). SKI provides evidence on Indonesia's health status, covering communicable/noncommunicable diseases, maternal-child health, and more, to guide policy at national, provincial, and district levels.

It employed stratified, multistage systematic random sampling with probability proportional to size (PPS) across 38 provinces. Stage 1 selected 30 000 primary sampling units (PSUs) from the 2020 Population Census; Stage 2 chose census blocks (CBs) per PSU by PPS; Stage 3 picked 25 households per CB. SKI 2023 targeted 34 500 CBs and 340 555 households, successfully interviewing 34 065 CBs (98.7%), 315 646 households (91.5%), and 1 082 958 individuals.

Trained enumerators, guided by local health authorities and leaders, gathered data *via* face-to-face structured questionnaires after informed consent. All household members participated, with guardians for those <15 years. Topics included health access, mental/environmental health, communicable diseases (*e.g.*, lymphatic

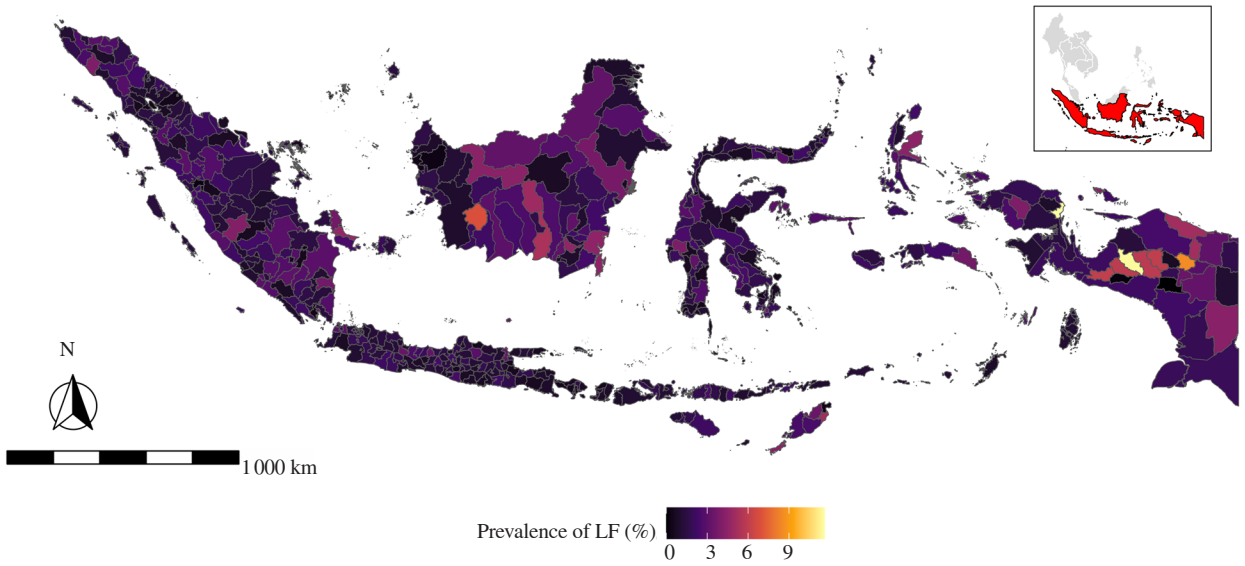

Figure 1. Prevalence of lymphatic filariasis at district-level, Indonesia, based on the 2023 Indonesian Health Survey (Survei Kesehatan Indonesia, SKI). LF: lymphatic filariasis.

filariasis), noncommunicable diseases, disability, oral/reproductive health, knowledge-attitude-practice (KAP), child immunization, and nutrition[3].

2.3. Sample

In the present study, we utilized a subset of SKI 2023 data. The study included 877 531 participants from 38 provinces. We classified the participants into those who lived in urban (n=469 549) and rural areas (n=407 982). The definitions of urban and rural areas are as follows: (1) Urban villages: villages or administrative areas categorized as urban, typically characterized by higher population density, better infrastructure, and access to public services; (2) Rural villages: villages or administrative areas classified as rural, often characterized by lower population density, limited infrastructure, and fewer public services, generally located in more remote areas[18]. According to the Central Bureau of Statistics of Indonesia (BPS) data for 2022, 56.4% of Indonesia's population lives in urban areas[19].

2.4. Variables

The outcome variable of this study was the participants' compliance with MDA for filariasis. In SKI 2023, each participant was asked: "Had the participant taken the filariasis prevention drugs (DEC and/or albendazole) given by the healthcare workers (doctor/nurse/midwife) or cadres in the past 5 years?" The outcome variable is coded as "1" if "Yes" and "0" if "No."

The explanatory variables were individual characteristics, including sex (female, male), age group (2-5 years, 6-18 years, 19-45 years, 46-60 years, >60 years), education level (no education, primary, secondary, higher), employment status (nonworking age, unemployed, student, formal sector worker, informal sector worker, farmer, fisherman), self-reported LF (yes, no), wealth index (quintile 1, 2, 3, 4, and 5), mobile phone ownership (yes, no), awareness of health facility (yes, no), travel time to the nearest health facility (less than 30 minutes), affordability of transportation costs (yes, no), and individual mosquito preventive measures (no, yes).

2.5. Data analysis

Descriptive analysis summarized participant characteristics, frequencies, and weighted proportions. Bivariate logistic regression analysis were conducted separately for urban and rural populations to estimate crude odds ratios (*OR*s) with 95% *CI*s; variables with P<0.25 in the respective bivariate analyses were included in the corresponding multivariate logistic regression models. Stepwise backward elimination retained confounders changing *OR*s >10%. Adjusted odds ratios (a*OR*s) and 95% (*CI*s) were reported; with statistical significance set at P<0.05. Survey data weighted using STATA 17.0 MP 'svy' command for clustering/sampling adjustment. Map of LF prevalence and MDA was created in R (version 4.4.1) environment with the "ggplot2" and "sf" packages. The basemap (in shapefile) of district-level administrative boundary of Indonesia was obtained from the Global Administrative Areas database (https://gadm.org/index.html).

3. Results

3.1. Sample characteristics

The study included 877 531 participants across 38 provinces in Indonesia (Table 1), with a fairly balanced distribution between

Table 1. The general characteristics of the participants in urban (*n*= 469549) and rural (*n*=407982) areas of Indonesia.

Participant characteristics	Urban	Rural
Age group, years, *n* (%)		
2-5	44948 (8.33)	42242 (8.49)
6-18	99829 (20.8)	83080 (21.51)
19-45	173648 (42.45)	155137 (41.96)
46-60	96259 (18.17)	79927 (17.51)
>60	47707 (10.25)	40625 (10.53)
Sex, *n* (%)		
Female	248283 (49.6)	214986 (49.33)
Male	221266 (50.4)	192996 (50.67)
Education level, *n* (%)		
No education	77627 (14.44)	83174 (18.06)
Primary	213421 (46.3)	233499 (60.17)
Secondary	127426 (29.65)	69965 (17.73)
Higher	51075 (9.62)	21344 (4.04)
Employment status, *n* (%)		
Pre-working age	86787 (15.73)	79457 (16.24)
Unemployed	114524 (24.83)	91418 (23.53)
Student	59907 (13.95)	45394 (12.69)
Formal sector	61104 (15.12)	21294 (5.37)
Informal sector	114360 (24.93)	63483 (18.81)
Farmer	29369 (4.97)	101364 (22.57)
Fisherman	3498 (0.48)	5572 (0.8)
Wealth index, *n* (%)		
Quintile 1	51598 (10.42)	120796 (27.41)
Quintile 2	80664 (17.93)	85668 (24.02)
Quintile 3	97153 (21.7)	75588 (22.65)
Quintile 4	103829 (23.03)	60916 (16)
Quintile 5	129148 (26.93)	39830 (9.91)
Mobile phone ownership, *n* (%)		
Yes	442667 (93.78)	362415 (88.95)
No	26860 (6.22)	45528 (11.05)
Aware of health facility, *n* (%)		
Yes	468976 (99.89)	406708 (99.72)
No	573 (0.11)	1274 (0.28)
Travel time to the nearest health facility less than 30 minutes? *n* (%)		
Yes	466402 (99.54)	368251 (93.94)
No	3147 (0.46)	39731 (6.06)
Affordability of transportation costs, *n* (%)		
Yes	466958 (99.41)	390404 (97.08)
No	2591 (0.59)	17578 (2.92)
Individual mosquito preventive measures, *n* (%)		
No	121537 (26.34)	72431 (24.53)
Yes	348012 (73.66)	335551 (75.47)
Self-reported LF, *n* (%)		
Yes	6958 (1.44)	7323 (1.67)
No	462591 (98.56)	400659 (98.33)
Had been given anti-filarial preventive drug in the past 5 years (*n*=877531), *n* (%)		
Yes	52173 (45.88)	61552 (54.12)
No	204589 (57.31)	152421 (42.69)
Not applicable (not MDA priority area)	255640 (62.84)	151155 (37.16)
Had taken anti-filarial preventive drug given by healthcare worker or cadre (*n*=136526), *n* (%)		
Yes	38775 (70.54)	70638 (81.15)
No	13134 (29.46)	13979 (18.85)

LF: lymphatic filariasis; MDA: mass drug administration.

urban (n=469 549; 53.5%) and rural areas (n=407 982; 46.5%). Most participants were aged between 19 and 45 years, representing a productive age group. The sex distribution was relatively equal across both settings. In terms of education level, most participants had completed primary education, both in urban and rural settings, with a significantly greater proportion in rural areas (60.17%) than in urban areas (46.3%).

The employment status distribution reflected the expected urban–rural differences, where farming was the predominant occupation in rural areas (22.57%), while most urban participants were engaged in the informal sector (24.93%). The proportion of unemployed participants was relatively equal in both settings. According to the wealth index, a high proportion of urban participants belong to the highest wealth quintile (26.93%), whereas most rural participants fall into the lowest wealth quintile (27.41%). Mobile phone ownership was high among participants in both urban (93.78%) and rural (88.95%) areas. Most participants, regardless of their setting, were aware of nearby healthcare facilities, and most reported that they could reach these facilities within 30 minutes and afford transportation costs. In both settings, approximately two-thirds of the participants reported practicing preventive measures against mosquito bites.

A small proportion of participants reported having been laboratory-diagnosed with LF by local healthcare workers (urban: 1.44%; rural: 1.67%). Over the past 5 years, a total of 136 526 participants reported receiving an antifilarial drug from local health authorities. Among these, a notable fraction did not take anti-filarial drugs as suggested (urban: 29.46%; rural: 18.85%).

3.2. Spatial variation of participants taking MDA for filariasis in Indonesia

The geographical distribution of participants' compliance with MDA for LF at the district level across Indonesia is presented in Figure 2 and Figure 3. A low proportion of participants' compliance with the MDA for LF (less than 25%) was observed in 27 districts.

Table 2 summarizes the distribution of participants who had never taken MDA medication according to place of residence. Significant urban rural disparities were observed across most participant characteristics, including age group, sex, educational attainment, employment status, wealth index, mobile phone ownership, travel time to the nearest health facility, transportation affordability, and individual mosquito preventive practices (all P<0.05). In contrast, self-reported LF and awareness of nearby health facilities did not differ significantly between urban and rural participants (P=0.499 and P=0.159, respectively).

Among participants who had never taken MDA medication, the proportion of urban residents increased with age, reaching 59.94% (95% *CI* 57.21-62.60) among those aged 46-60 years, compared with 40.06% in rural areas (P=0.001). Urban participants also accounted for a higher proportion of females than rural participants (58.23% *vs.* 41.77%, P=0.010). The urban proportion was substantially higher among individuals with secondary education (67.42% *vs.* 32.58%) and higher education (72.24% *vs.* 27.76%) (both P<0.001). Likewise, formal-sector workers (76.16% *vs.* 23.84%) and informal-sector workers (65.28% *vs.* 34.72%) were predominantly urban, whereas farmers were predominantly rural (23.33% *vs.* 76.67%)

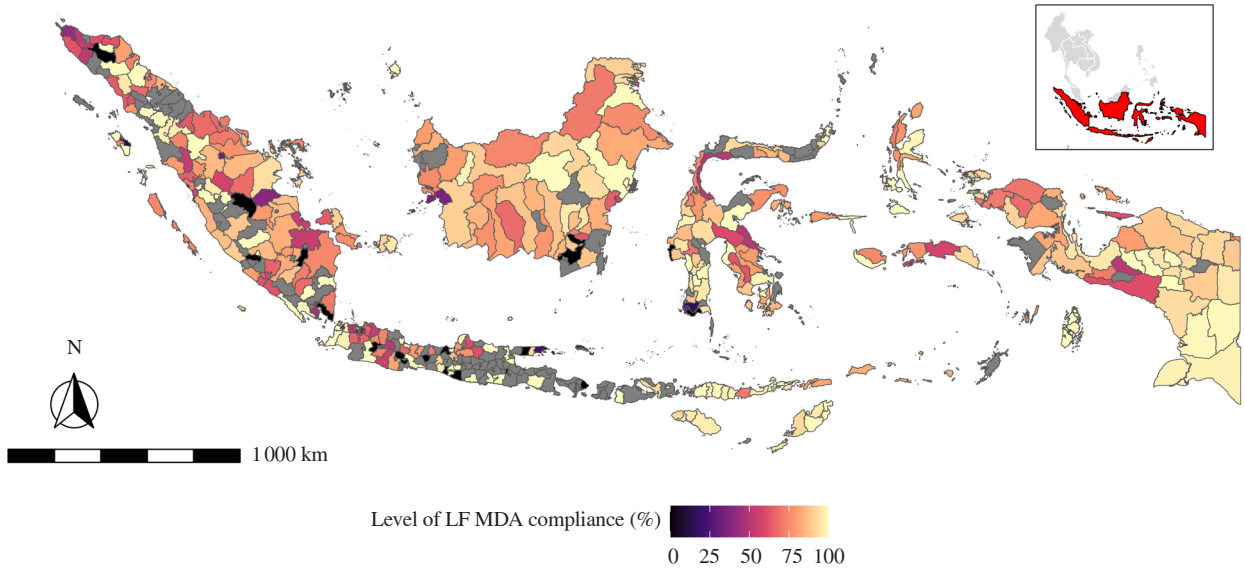

Figure 2. The proportion of participants taking preventive chemotherapy for LF at district-level in Indonesia, based on 2023 Indonesian Health Survey (Survei Kesehatan Indonesia, SKI). LF: lymphatic filariasis; MDA: mass drug administration.

(P<0.001). The proportion of urban residents also increased across wealth quintiles, from 32.96% in the poorest quintile to 75.69% in the richest quintile (P<0.001). In contrast, rural residents were more likely to have no formal education (51.25% *vs.* 48.75%), require 30 minutes to reach the nearest health facility (87.49% *vs.* 12.51%), and report transportation costs as unaffordable (70.22% *vs.* 29.78%) (all P<0.001). These variables were subsequently evaluated in regression analyses to identify factors independently associated with MDA noncompliance.

In the weighted prevalence analysis (Table 3), MDA noncompliance was consistently higher in urban than rural areas across nearly all subgroups. Urban prevalence was notably elevated among children aged 2-5 years (36.91%), adults >60 years (30.22%), individuals with no formal education (33.04%), and pre-working age individuals (34.70%), while rural noncompliance peaked among the same young age group (30.24%) and those with no education (22.46%), but with

Table 2. Distribution of participants who had never taken mass drug administration (MDA) medication for lymphatic filariasis according to place of residence in Indonesia.

Participant characteristics	*N*	Urban % (95% *CI*)	Rural % (95% *CI*)	*P* value
Age group				0.001
2-5 years	1518	51.39 (46.69-56.07)	48.61 (43.93-53.31)	
6-18 years	7043	54.20 (51.33-57.03)	45.80 (42.97-48.67)	
19-45 years	10434	57.93 (55.63-60.19)	42.07 (39.81-44.37)	
46-60 years	5583	59.94 (57.21-62.60)	40.06 (37.40-42.79)	
>60 years	2482	56.88 (53.12-60.57)	43.12 (39.43-46.88)	
Sex				0.010
Female	14531	58.23 (56.20-60.22)	41.77 (39.78-43.80)	
Male	12582	55.70 (53.44-57.94)	44.30 (42.06-46.56)	
Education level				<0.001
No education	3438	48.75 (44.56-52.95)	51.25 (47.05-55.44)	
Primary	15569	52.48 (50.18-54.76)	47.52 (45.24-49.82)	
Secondary	6166	67.42 (64.84-69.89)	32.58 (30.11-35.16)	
Higher	1940	72.24 (68.00-76.11)	27.76 (23.89-32.00)	
Employment status				<0.001
Pre-working age	4172	52.30 (49.13-55.44)	47.70 (44.56-50.87)	
Unemployed	7195	60.31 (57.81-62.76)	39.69 (37.24-42.19)	
Student	3885	57.00 (53.29-60.63)	43.00 (39.37-46.71)	
Formal sector	2062	76.16 (72.45-79.52)	23.84 (20.48-27.55)	
Informal sector	5606	65.28 (62.61-67.87)	34.72 (32.13-37.39)	
Farmer	3876	23.33 (20.23-26.74)	76.67 (73.26-79.77)	
Fisherman	317	48.46 (37.88-59.18)	51.54 (40.82-62.12)	
Self-reported lymphatic filariasis				0.499
Yes	752	59.10 (52.75-65.17)	40.90 (34.83-47.25)	
No	26361	56.93 (55.00-58.85)	43.07 (41.15-45.00)	
Wealth index				<0.001
Quintile 1	4904	32.96 (29.32-36.83)	67.04 (63.17-70.68)	
Quintile 2	5099	51.24 (47.26-55.21)	48.76 (44.79-52.74)	
Quintile 3	5662	58.42 (54.97-61.79)	41.58 (38.21-45.03)	
Quintile 4	5481	65.82 (62.61-68.88)	34.18 (31.12-37.39)	
Quintile 5	4987	75.69 (72.58-78.55)	24.31 (21.45-27.42)	
Mobile phone ownership				0.001
Yes	24980	57.69 (55.76-59.60)	42.31 (40.40-44.24)	
No	2133	48.11 (42.49-53.79)	51.89 (46.21-57.51)	
Awareness of nearby health facility				0.159
Yes	27068	57.01 (55.10-58.91)	42.99 (41.09-44.90)	
No	45	37.54 (16.28-65.00)	62.46 (35.00-83.72)	
Travel time to the nearest health facility				<0.001
<30 minutes	25816	58.28 (56.35-60.19)	41.72 (39.81-43.65)	
≥30 minutes	1297	12.51 (8.11-18.81)	87.49 (81.19-91.89)	
Affordability of transportation costs				<0.001
Affordable	26545	57.35 (55.43-59.26)	42.65 (40.74-44.57)	
Not affordable	568	29.78 (19.28-42.95)	70.22 (57.05-80.72)	
Individual mosquito preventive measures				<0.001
No		64.87 (61.32-68.27)	35.13 (31.73-38.68)	
Yes		54.86 (52.83-56.87)	45.14 (43.13-47.17)	

CI: confidence interval; MDA: mass drug administration; LF: lymphatic filariasis. *P* values were calculated to compare the distribution of participants who had never taken MDA medication between urban and rural settings.

Table 3. Weighted prevalence of MDA noncompliance among participants who received anti-filarial drugs, according to participant characteristics in urban and rural Indonesia (n=136 526).

Participant characteristics	Urban			Rural		
	N	*n*	% (95% *CI*)	*N*	*n*	% (95% *CI*)
Age group, years						
2-5	2 057	654	36.91 (32.98-41.03)	3 281	864	30.24 (27.40-33.24)
6-18	12 337	3 365	30.53 (28.45-32.69)	18 749	3 678	20.87 (19.60-22.20)
19-45	21 369	5 050	28.95 (27.38-30.57)	36 368	5 384	17.68 (16.67-18.74)
46-60	11 640	2 846	27.92 (25.97-29.96)	18 603	2 737	17.01 (15.86-18.24)
>60	4 464	1 206	30.22 (27.52-33.05)	7 490	1 276	19.38 (17.71-21.17)
Sex						
Female	28 841	7 189	29.59 (28.21-30.99)	45 794	7 342	18.60 (17.70-19.53)
Male	23 068	5 945	29.33 (27.73-30.99)	38 823	6 637	19.11 (18.14-20.11)
Education level						
No education	4 735	1 423	33.04 (30.26-35.95)	9 708	2 015	22.46 (20.33-24.75)
Primary	27 403	6 872	29.11 (27.58-30.70)	54 405	8 697	18.54 (17.60-19.52)
Secondary	14 030	3 572	30.11 (28.14-32.15)	15 528	2 594	18.68 (17.36-20.07)
Higher	5 741	1 267	26.18 (23.44-29.11)	4 976	673	15.96 (13.92-18.24)
Employment status						
Pre-working age	6 084	1 878	34.70 (32.12-37.37)	9 484	2 294	26.31 (24.60-28.09)
Unemployed	14 179	3 689	29.70 (28.04-31.42)	21 062	3 506	18.81 (17.60-20.08)
Student	7 630	1 907	29.49 (26.74-32.39)	11 228	1 978	19.50 (18.06-21.03)
Formal sector	6 540	1 382	27.41 (24.98-29.98)	5 256	680	16.57 (14.39-19.00)
Informal sector	13 119	3 318	29.58 (27.71-31.51)	13 740	2 288	19.40 (18.04-20.84)
Farmer	3 854	823	24.00 (21.12-27.14)	22 513	3 053	15.97 (14.71-17.31)
Fisherman	503	137	28.77 (22.00-36.64)	1 334	180	13.50 (9.25-19.30)
Self-reported LF						
Yes	1 109	352	38.00 (32.22-44.14)	1 717	400	25.34 (21.66-29.42)
No	50 800	12 782	29.29 (27.98-30.64)	82 900	13 579	18.74 (17.90-19.60)
Wealth index						
Quintile 1	5 980	1 359	23.88 (21.27-26.70)	27 266	3 545	14.99 (13.86-16.21)
Quintile 2	8 818	2 268	30.16 (27.34-33.14)	16 604	2 831	20.33 (18.66-22.11)
Quintile 3	11 138	2 907	29.72 (27.36-32.19)	15 026	2 755	20.60 (18.98-22.33)
Quintile 4	11 746	3 013	30.35 (28.07-32.74)	12 861	2 468	19.83 (18.27-21.50)
Quintile 5	13 503	3 421	30.40 (28.08-32.81)	8 206	1 566	22.14 (19.83-24.63)
Mobile phone ownership						
Yes	49 011	12 436	29.52 (28.20-30.88)	74 951	12 544	19.19 (18.32-20.09)
No	2 892	698	28.65 (24.57-33.11)	9 657	1 435	15.95 (14.36-17.69)
Aware of health facility						
Yes	51 881	13 124	29.45 (28.15-30.79)	84 429	13 944	18.85 (18.01-19.71)
No	28	10	53.01 (30.60-74.28)	188	35	21.33 (11.24-36.73)
Travel time to the nearest health facility						
Yes	51 330	13 028	29.48 (28.17-30.83)	74 650	12 788	19.42 (18.53-20.33)
No	579	106	26.79 (19.28-35.93)	9 967	1 191	12.76 (10.70-15.15)
Affordability of transportation costs						
Yes	51 637	13 081	29.43 (28.13-30.77)	79 887	13 464	19.18 (18.32-20.07)
No	272	53	35.30 (22.45-50.69)	4 730	515	10.66 (8.82-12.84)
Individual mosquito preventive measures						
No	10 430	2 923	31.41 (29.28-33.63)	9 852	1 811	20.07 (18.31-21.97)
Yes	41 479	10 211	28.89 (27.50-30.33)	74 765	12 168	18.61 (17.74-19.51)

N represents the total number of participants within each subgroup who reported receiving anti-filarial drugs during the previous five years; *n* represents the number of participants who were noncompliant with MDA. Estimates are weighted using the complex survey design. *CI*: confidence interval.

generally lower rates across all categories. Wealth gradients were modest in both settings, though urban rates remained relatively stable (~24%-30%) across quintiles, whereas rural rates ranged from 15% (poorest) to 22% (richest). Notably, urban noncompliance persisted at approximately 29%-30% even among participants with favorable access indicators, including mobile phone ownership, awareness of health facilities, short travel time (<30 minutes), affordable transportation, and individual mosquito prevention, whereas rural residents with similar advantages reported substantially lower noncompliance (~18%-19%). These findings indicate that while rural noncompliance is closely associated with structural and economic barriers, urban noncompliance appears to be driven by behavioral,

Table 4. Bivariate and multivariate logistic regression analysis of factors associated with non-compliance to MDA in urban and rural areas, Indonesia; weighted and adjusted for survey design (*n*=136526).

Participant characteristics	Urban		Rural	
	Crude *OR* (95% *CI*)	a*OR* (95% *CI*)	Crude *OR* (95% *CI*)	a*OR* (95% *CI*)
Age group, years				
2-5	1.51 (1.26-1.82)***	1.15 (0.83-1.58)	2.11 (1.81-2.47)***	1.43 (1.08-1.87)*
6-18	1.13 (1.01-1.28)*	1.02 (0.83-1.26)	1.29 (1.16-1.42)***	1.07 (0.91-1.25)
19-45	1.05 (0.95-1.16)	1.04 (0.93-1.15)	1.05 (0.96-1.14)	1.02 (0.92-1.12)
46-60	Reference	Reference	Reference	Reference
>60	1.12 (0.96-1.30)	1.20 (1.02-1.41)*	1.17 (1.05-1.32)**	1.28 (1.14-1.44)***
Sex				
Female	Reference	-	Reference	Reference
Male	0.99 (0.92-1.06)	-	1.03 (0.98-1.09)	1.09 (1.02-1.17)*
Education level				
No education	1.39 (1.16-1.68)***	1.19 (0.92-1.53)	1.53 (1.25-1.86)***	1.22 (0.9-1.66)
Primary	1.16 (0.99-1.35)	1.16 (0.97-1.39)	1.20 (1.01-1.42)*	1.25 (1.02-1.53)*
Secondary	1.21 (1.03-1.43)*	1.21 (1.02-1.44)*	1.21 (1.02-1.44)*	1.23 (1.01-1.49)*
Higher	Reference	Reference	Reference	Reference
Employment status				
Pre-working age	1.68 (1.4-2.03)***	1.58 (1.21-2.07)**	1.88 (1.66-2.13)***	1.66 (1.34-2.07)***
Unemployed	1.34 (1.13-1.59)**	1.29 (1.07-1.54)**	1.22 (1.09-1.36)***	1.25 (1.08-1.43)**
Student	1.32 (1.08-1.63)**	1.30 (0.98-1.73)	1.28 (1.14-1.43)***	1.24 (1.04-1.47)*
Formal sector	1.20 (0.98-1.46)	1.15 (0.93-1.42)	1.05 (0.86-1.27)	1.05 (0.84-1.31)
Informal sector	1.33 (1.12-1.58)**	1.28 (1.07-1.53)**	1.27 (1.12-1.43)***	1.23 (1.08-1.41)**
Farmer	Reference	Reference	Reference	Reference
Fisherman	1.28 (0.86-1.89)	1.31 (0.86-2.00)	0.82 (0.53-1.27)	0.83 (0.5-1.36)
Self-reported LF				
Yes	1.48 (1.14-1.91)**	1.47 (1.13-1.91)**	1.47 (1.2-1.81)***	1.47 (1.19-1.82)***
No	Reference	Reference	Reference	Reference
Wealth index				
Quintile 1	Reference	Reference	Reference	Reference
Quintile 2	1.38 (1.13-1.68)**	1.37 (1.12-1.67)**	1.45 (1.27-1.65)***	1.39 (1.21-1.59)***
Quintile 3	1.35 (1.13-1.61)**	1.34 (1.12-1.6)**	1.47 (1.29-1.67)***	1.39 (1.22-1.59)***
Quintile 4	1.39 (1.17-1.65)***	1.39 (1.17-1.65)***	1.40 (1.23-1.6)***	1.32 (1.15-1.52)***
Quintile 5	1.39 (1.16-1.67)***	1.43 (1.18-1.72)***	1.61 (1.37-1.9)***	1.55 (1.31-1.85)***
Mobile phone ownership				
Yes	1.04 (0.85-1.29)	-	1.25 (1.1-1.42)***	1.40 (1.12-1.75)**
No	Reference	-	Reference	Reference
Aware of health facility				
Yes	0.37 (0.14-0.95)*	0.29 (0.11-0.77)*	0.86 (0.4-1.84)	-
No	Reference	Reference	Reference	-
Travel time to the nearest health facility				
Yes	1.14 (0.74-1.76)	-	1.65 (1.34-2.02)***	1.40 (1.12-1.75)**
No	Reference	-	Reference	Reference
Affordability of transportation costs				
Yes	0.76 (0.41-1.44)	-	1.99 (1.6-2.46)***	1.55 (1.21-1.99)***
No	Reference	-	Reference	Reference
Individual mosquito preventive measures				
No	Reference	Reference	Reference	-
Yes	1.13 (1.01-1.25)*	1.12 (1-1.25)*	1.10 (0.98-1.24)	-

a*OR*: adjusted odds ratio; *CI*: confidence interval; *P< 0.05; **P< 0.01; ***P<0.001. -: multivariate analysis was not conducted.

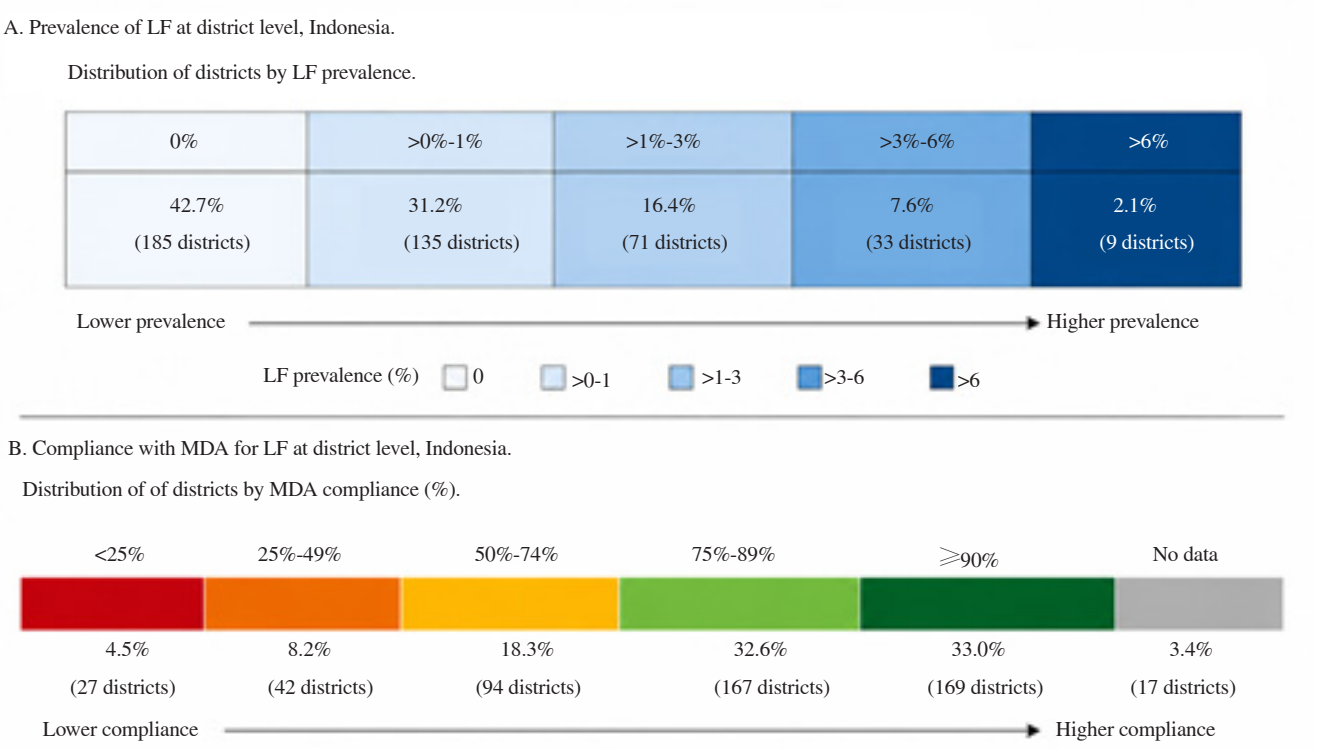

Figure 3. Geographical distribution of LF prevalence and compliance with MDA at district level of Indonesia. data source: 2023 Indonesian Health Survey (Survei Kesehatan Indonesia, SKI). LF: lymphatic filariasis; MDA: mass drug administration.

perceptual, or lifestyle factors that operate independently of physical access to healthcare services.

Both bivariate and multivariable logistic regression analyses were performed to examine factors associated with noncompliance with MDA for LF (Table 4). Variables with $P<0.25$ in the bivariate analysis were entered into the multivariable model. Candidate variables for the urban model included age group, education level, employment status, self-reported LF, wealth index, awareness of nearby health facilities, and individual mosquito preventive practices. For the rural model, additional variables including sex, mobile phone ownership, travel time to the nearest health facility, and transportation affordability were also considered.

In urban areas, the multivariable analysis identified several independent predictors of MDA noncompliance. Individuals aged over 60 years had higher odds of noncompliance than those aged 46-60 years (a*OR* 1.2; 95% *CI* 1.02-1.41). Compared with participants with higher education, those with secondary education were also more likely to be noncompliant (a*OR* 1.21; 95% *CI* 1.02-1.44). Employment status remained significantly associated with noncompliance, particularly among pre-working age group (a*OR* 1.58; 95% *CI* 1.21-2.07) and unemployed (a*OR* 1.29; 95% *CI* 1.07-1.54) and informal-sector workers (a*OR* 1.28; 95% *CI* 1.07-1.53). Participants with self-reported LF had increased odds of noncompliance (a*OR* 1.47; 95% *CI* 1.13-1.91). Compared with those in the lowest wealth quintile (quintile 1), urban participants in wealth quintiles 2, 3, 4, and 5 had significantly greater odds of MDA noncompliance, with a*OR*s of 1.37 (95% *CI* 1.12-1.67), 1.34 (95% *CI* 1.12-1.60), 1.39 (95% *CI* 1.17-1.65), and 1.43 (95% *CI* 1.18-1.72), respectively. Similarly, rural participants in wealth quintiles 2, 3, 4, and 5 had higher odds of noncompliance, with a*OR*s of 1.39 (95% *CI* 1.21-1.59), 1.39 (95% *CI* 1.22-1.59), 1.32 (95% *CI* 1.15-1.52), and 1.55 (95% *CI* 1.31-1.85), respectively. Conversely, awareness of nearby health facilities was associated with lower odds of noncompliance (a*OR* 0.29; 95% *CI* 0.11-0.77). Participants reporting individual mosquito preventive practices also had slightly higher odds of noncompliance (a*OR* 1.12; 95% *CI* 1.00-1.25).

In rural areas, the final multivariable model identified age group, sex, education level, employment status, self-reported LF, wealth index, mobile phone ownership, travel time to the nearest health facility, and transportation affordability as independent predictors of MDA noncompliance. Participants aged over 60 years (a*OR* 1.28; 95% *CI* 1.14-1.44) had significantly higher odds of noncompliance than those aged 46-60 years. Male participants were more likely to be noncompliant than females (a*OR* 1.09; 95% *CI* 1.02-1.17). Primary and secondary education were associated with increased odds of noncompliance compared with higher education (a*OR* 1.25; 95% *CI* 1.02-1.53 and a*OR* 1.23; 95% *CI* 1.01-1.49, respectively). Higher odds of noncompliance were also observed among pre-working age individuals (a*OR* 1.66; 95% *CI* 1.34-2.07), unemployed participants (a*OR* 1.25; 95% *CI* 1.08-1.43), students (a*OR* 1.24;

95% *CI* 1.04-1.47), and informal-sector workers (a*OR* 1.23; 95% *CI* 1.08-1.41), compared with farmers. Self-reported LF remained significantly associated with MDA noncompliance in both settings. Compared with participants without self-reported LF, those with self-reported LF had higher odds of noncompliance in urban areas areas (a*OR* 1.47; 95% *CI* 1.13-1.91) and in rural areas (a*OR* 1.47; 95% *CI* 1.19-1.82).

4. Discussion

MDA remains the principal intervention strategy in the GPELF. By 2018, Indonesia had successfully scaled up MDA coverage to all endemic districts, reaching a total population of 41 857 397 individuals and achieving 77.7% coverage at both the program and national levels[20,21]. Despite these efforts, research results from 2023 show that LF persists in certain areas of Indonesia, even after five annual rounds of MDA. This highlights the need for the Ministry of Health of Indonesia to strengthen public health promotion to increase compliance with MDA[22]. The results of this study identified several factors that influence the noncompliance of MDA, including differences in population characteristics between urban and rural areas. Overall, noncompliance was greater in urban areas than in rural areas, despite urban residents facing fewer challenges related to travel time to the nearest health facilities and healthcare affordability. The lower compliance observed in urban settings may be attributed to the lack of social pressure commonly observed in rural villages, where community cohesion encourages participation in harmonized public health efforts.

Urban LF elimination faces challenges from high population mobility, rigid work schedules limiting MDA access, transient residences hindering follow-up, and distrust in frontline workers who prefer doctor-prescribed drugs[21,23]. In general, the characteristics of urban populations combined with ineffective health communication strategies contribute to reduced MDA compliance in urban areas. When we examined the factors contributing to MDA noncompliance in urban settings more closely, we found that individuals of productive age, females, those with higher education levels, individuals in the wealthier quintiles (4 and 5), those who owned mobile phones, and those who did not engage in individual mosquito prevention measures were more likely to be noncompliant. These findings suggest that, in urban areas, MDA noncompliance is not necessarily driven by limited socioeconomic resources or poor access to information. Rather, individuals with relatively higher socioeconomic status, including higher educational attainment, greater household wealth, and mobile phone ownership, were also more likely to be noncompliant. Although these individuals possess socioeconomic advantages that could facilitate access to health information and preventive services, these advantages do not necessarily translate into participation in MDA. This pattern may reflect a lower perceived risk of LF in urban settings, where the disease is often perceived as predominantly affecting rural populations. Similar findings have been reported in other studies, such as those conducted in Tanzania[4] and India[25,26].

Furthermore, efforts to increase health knowledge and foster a positive attitude toward MDA are needed. First, health knowledge about the importance of MDA must be intensified and targeted across the entire community. Flexible drug distribution options, combined with proactive engagement by health professionals, are also needed to increase community awareness and prioritize the uptake of LF medication[27]. Awareness campaigns are crucial for highlighting the risks and complications of illness and persuading the public of the advantages of living in a society free of filariasis[28].

In rural areas, MDA noncompliance was associated with demographic, socioeconomic, and healthcare access factors. Specifically, higher odds of noncompliance were observed among males, participants with primary or secondary education, pre-working-age individuals, unemployed participants, students, and informal-sector workers, as well as those with self-reported LF. Interestingly, noncompliance was also associated with higher household wealth (quintiles 2-5), mobile phone ownership, longer travel time to the nearest health facility, and unaffordable transportation costs. Even mosquito prevention users showed poor adherence, likely due to low socioeconomic status limiting health info access. Communities may view personal prevention as sufficient against LF transmission. Notably, lacking prevention had no effect, possibly from poor mosquito-LF knowledge awareness[6,29]. This contrasts with urban findings, where not using mosquito preventive measures was linked to higher odds of noncompliance. Lack of program knowledge is the top reason for avoiding LF MDA tablets. Positive attitudes and awareness drive behavior change, so comprehensive information on MDA and disease must reach communities effectively. Rural males/farmers often skip doses fearing routine disruption; access/affordability barriers persist. Proactive strategies—tailored to beneficiaries' needs and urban/rural contexts are vital for success through better info dissemination[27,30,31].

In both settings (rural and urban), the highest risk of noncompliance was found for individuals who were categorized into the pre-working group (a*OR*s of 1.58 and 1.66, respectively). The pre-working or nonworking group is the population under 15 years old and above 65 years old. The health-seeking behavior of the population under 15 years of age and above 65 years of age is often influenced by factors such as family support from parents or caregivers. Parents have the influence to decide on the treatment for their child. In addition, family decisions could be influenced by trust in the safety of the drug for children and fear of adverse effects, including concerns about age-related risk or potential drug interactions. Noncompliance

of the nonworking group could also stem from the perception that children or their elderly family members do not exhibit symptoms or morbidity related to filariasis. Therefore, educational programs should clearly communicate information about the MDA program, potential side effects, and possible drug interactions, especially for groups with chronic diseases, such as diabetes or hypertension. This information should also be conveyed to family members to help people understand and ensure that all eligible individuals participate in MDA without any concerns. The WHO recommends that all individuals at risk of LF transmission, except those under 2 years of age, are eligible for MDA. Consequently, MDA programs must effectively reach all age groups, including child youth and elderly individuals from preworking groups[5-7].

This study has several limitations. First, its cross-sectional design precludes causal inference, and the identified associations should not be interpreted as causal relationships. Second, the analysis relied on secondary data from the SKI 2023, limiting the variables available for analysis. Important determinants of MDA noncompliance, such as knowledge of LF, attitudes toward MDA, perceived adverse drug reactions, trust in healthcare workers, exposure to health promotion activities, and community-level social influences, were not available in the dataset. Third, MDA compliance was based on participants' self-reported drug intake during the previous five years, which may be subject to recall and social desirability bias. Finally, although the survey was nationally representative and adjusted for the complex sampling design, residual confounding from unmeasured individual and contextual factors cannot be excluded. Future longitudinal and mixed-methods studies are warranted to better understand the causal pathways and behavioral mechanisms underlying MDA noncompliance in different geographic settings.

In conclusion, this study reveals context-specific determinants MDA noncompliance for LF in Indonesia. Rural noncompliance was primarily associated with limited healthcare access, low education, and socioeconomic constraints, while urban noncompliance persisted despite better access and was more linked to behavioral, perceptual, and lifestyle issues. These findings highlight the need equity-focused strategies: structural improvements for rural communities and behavior-targeted interventions for urban ones. Key steps include enhanced health communication, frontline worker trust-building, flexible drug delivery, and community awareness. However, the findings should be interpreted in light of several limitations, including the cross-sectional design, reliance on secondary self-reported data, and the absence of important behavioral and psychosocial variables (*e.g.*, knowledge, attitudes, trust, and perceived adverse events), which may have resulted in residual confounding. Future mixed methods/longitudinal studies on cultural perceptions and trust are needed to refine interventions, supporting Indonesia's and global LF elimination by 2030.

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.

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Ethical approval

The Ministry of Health conducts the 2023 Indonesia National Health Survey following the Helsinki Declaration. The National Ethics Commission approved it for Health Research, Health Polytechnic Jakarta, the Ministry of Health of the Republic of Indonesia (ethic number: LB.02.01/I/L/287/2023; date: May 10th, 2023). The study deleted all participants' identities from the dataset. Participants have provided written approval for their involvement in the research. Before the interview, the interviewer gave consent forms to all family members. The survey interviewed parents or guardians (household heads, their spouses, or an older representative of the house) and all household members who consented.

Data availability statement

The data supporting this study's findings are available from the Center for Data and Information Technology, the Ministry of Health of the Republic of Indonesia, under license and cannot be freely available. Data can be made available after approval of a written request to the center for data and information technology, Ministry of Health, Republic of Indonesia (*via* Homepage-Layanan Permintaan Data | Kementerian Kesehatan RI). Permission to use the data was approved by the Center for Data and information Technology, Ministry of Health of Indonesia (ref No. 24095B8D01828004).

Authors' contribution

RW: Writing-original draft, review & editing, writing, conceptualization, methodology, formal analysis. MI: Writing-original draft, review & editing, writing, conceptualization, methodology, formal analysis, data curation. AH: Writing-review & editing, methodology, investigation, data curation. BE: Writing-original draft, review & editing, conceptualization, methodology. ANF: Writing-review & editing, methodology. NSH: Writing-review & editing, methodology. PWD: Writing-review & editing, conceptualization, methodology, formal analysis, data curation. TAG: Writing-review & editing, conceptualization, methodology, formal analysis.

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