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Rate of Asymptomatic Bacteriuria in Pregnancy, Associated Risk Factors, Causative Organisms, Antibiotic Sensitivity Pattern, and Cure Rate among Mothers Attending Antenatal Clinic in Teaching Hospital Peradeniya, Sri Lanka

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Abstract

Background: Asymptomatic bacteriuria (ABU) in pregnancy can progress to pyelonephritis and adverse maternal and perinatal outcomes if untreated. Contemporary data on ABU burden, risk factors, and antimicrobial susceptibility in Sri Lanka remain scarce. **Objectives:** To determine the prevalence of ABU in pregnancy, describe associated risk factors, compare urine full report (UFR) against urine culture diagnostically, identify causative organisms and antibiotic sensitivity patterns, and estimate the cure rate following culture-guided treatment. **Methods:** A longitudinal descriptive study was conducted at the Professorial Unit Antenatal Clinic, Teaching Hospital Peradeniya, Sri Lanka among 411 pregnant women. Midstream clean-catch urine samples were collected for UFR and culture on CLED agar; significant bacteriuria was defined as $\geq 10^5$ CFU/mL of a single organism. Culture-positive women received seven days of culture-guided antibiotics followed by a test-of-cure culture. Analysis used descriptive statistics, Fisher's exact test, and chi-square with Monte Carlo p-values ($p < 0.05$). **Results:** Among 411 women enrolled, 12 (2.9%; 95% CI: 1.5% - 5.0%) had culture-confirmed ABU. Predominant organisms were Staphylococci (41.7%), Streptococci (33.3%), and Coliforms (25.0%); Group B Streptococcus accounted for 25% of positive cultures. Nitrofurantoin was highly effective against Coliforms and Staphylococci; all

Streptococcal isolates were sensitive to ampicillin/amoxicillin. Two-thirds of Coliform isolates showed cephalosporin resistance. UFR pyuria demonstrated 100% sensitivity, 29.2% specificity, and 100% negative predictive value for ABU. Significant associations were identified with current gestational diabetes mellitus (OR = 13.13; p = 0.03), prior ABU history (OR = 53.33; p = 0.04), and significant pyuria (p = 0.04). Among 12 culture-positive women, 9 (75%) completed a test of cure, achieved microbiological cure and three (25%) defaulted follow up. **Conclusion:** ABU prevalence was relatively low but featured a distinctive pathogen profile with Staphylococcal predominance and notable Group B Streptococcus isolation. Cephalosporin resistance underscores the need for culture-guided treatment and ongoing antimicrobial surveillance. UFR pyuria is a useful screen but cannot replace urine culture as the diagnostic gold standard.

Keywords

Asymptomatic Bacteriuria, Pregnancy, Antenatal Screening, Antibiotic Sensitivity, Sri Lanka

1. Introduction

Urinary tract infection (UTI) is among the most common complications in obstetric practice, with an overall incidence of approximately 8% during pregnancy [1]. It can present as asymptomatic bacteriuria (ABU), acute cystitis, or pyelonephritis, each carrying significant implications for maternal and fetal health. ABU is defined as the presence of $\geq 10^5$ colony forming units per millilitre (CFU/mL) of a single bacterial species in the urine, without any accompanying signs or symptoms of infection, and affects 2% - 7% of pregnant women [2].

Pregnancy predisposes women to urinary tract colonization through a constellation of physiological changes. Progressive ureteric dilatation, beginning at approximately six weeks of gestation and peaking at 22 - 24 weeks, leads to urinary stasis and increased vesicoureteric reflux [3] [4]. Reduced detrusor tone, increased bladder capacity, and the mechanical pressure of the enlarging uterus further promote urinary stagnation [3]. Pregnancy-associated glycosuria and aminoaciduria enhance bacterial proliferation, while the physiological shift from cell-mediated to humoral immunity impairs bacterial eradication [5] [6]. During the third trimester, rising progesterone upregulates CD55 tissue receptors that facilitate Escherichia coli invasion [4].

The consequences of untreated ABU are serious. Approximately 30% of untreated women develop acute cystitis and up to 50% progress to pyelonephritis [7]. Beyond direct urinary complications, untreated ABU is associated with preterm labour, anaemia, pre-eclampsia, fetal growth restriction, and perinatal mortality [1]. Conversely, screening and treatment of ABU reduces pyelonephritis incidence from 20% - 35% to 1% - 4% and lowers preterm delivery rates from 53 to 14 per 1000 births [2].

Antimicrobial resistance among uropathogens implicated in pregnancy has become an increasingly pressing concern. A recent meta-analysis of observational studies reported that Gram-negative organisms account for the majority of urinary isolates in pregnancy, with resistance rates among Gram-positive isolates reaching as high as 95% for commonly used agents such as ampicillin [8]. These findings underscore the importance of culture-directed rather than purely empirical antibiotic selection in this population, particularly in settings where local resistance surveillance data remain limited.

Routine urine culture screening for ABU is not universally practiced in Sri Lanka. A 2012 study from Colombo documented a prevalence of 3.6%, with Coliforms and Staphylococci as the predominant organisms [3]. A subsequent study (2015-2016) from Colombo South confirmed Coliforms as the leading pathogen and demonstrated nitrofurantoin sensitivity across all isolates [9]. However, no updated prevalence or antimicrobial susceptibility data have emerged from other centres, and rapidly evolving antibiotic resistance patterns necessitate contemporaneous, regionally relevant data. This study was designed to address these gaps at Teaching Hospital Peradeniya.

2. Materials and Methods

2.1. Study Design and Setting

A longitudinal descriptive study was conducted at the Professorial Unit Antenatal Clinic, Teaching Hospital Peradeniya, Sri Lanka—one of two major teaching hospitals in the Central Province, serving mothers from across the Kandy district. Ethical approval was obtained from the Ethics Review Committee of the Faculty of Medicine, University of Peradeniya (Ref: 2019/EC/78) and institutional permission was granted from the Director and Consultants of the Professorial Obstetric Unit.

2.2. Participants

All mothers attending their first (booking) antenatal visit were eligible. Exclusion criteria were current urinary symptoms, fever, antibiotic use within the preceding month, known urinary tract anatomical abnormalities, and renal stones. Written informed consent was obtained from all participants prior to enrolment. Participation was entirely voluntary, with no impact on standard care upon withdrawal.

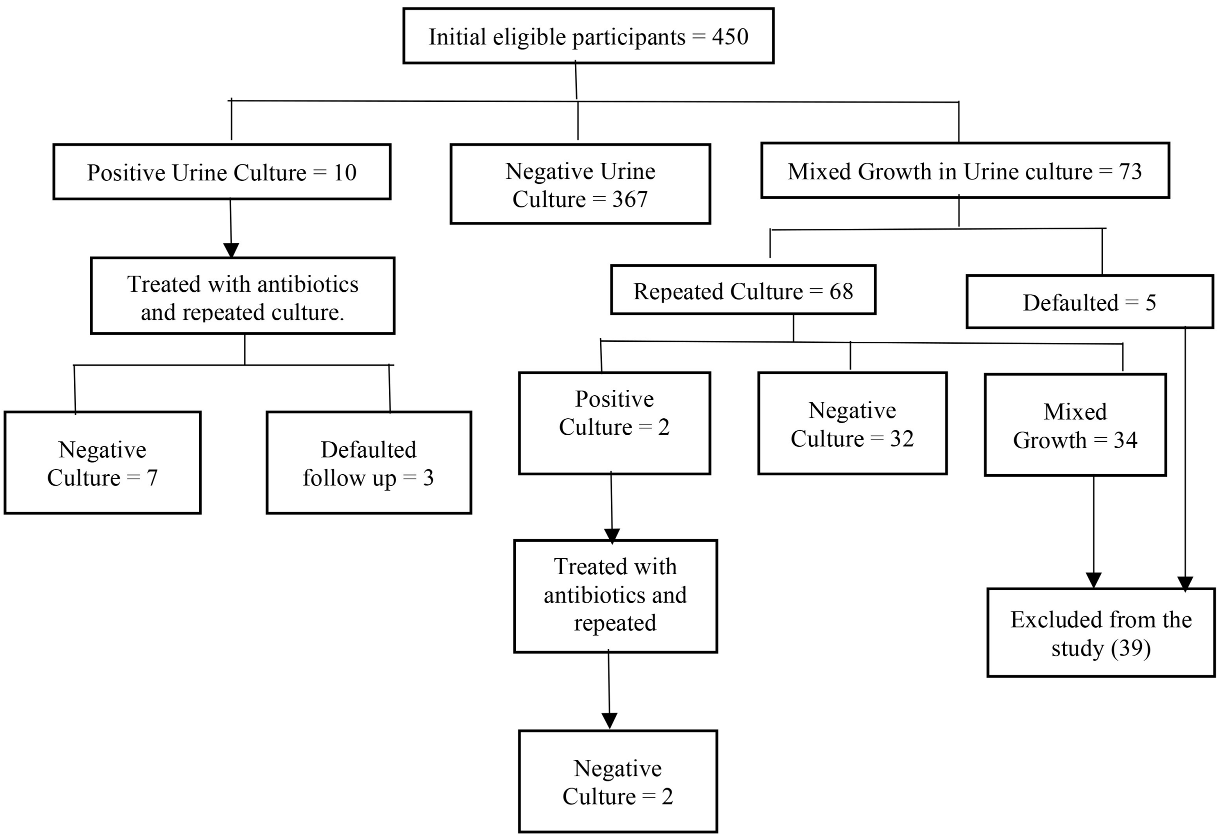
2.3. Sample Size

The minimum sample size was calculated using the single-proportion formula ($N = Z^2P[1 - P]/D^2$), with an expected prevalence of 4%, a 95% confidence interval ($Z = 1.96$), and a margin of error of 2% ($D = 0.02$), yielding a minimum of 369 participants [10]. A total of 450 participants were initially screened and ultimately 411 were enrolled over a 3-month period from April 2020 and June 2020.

2.4. Specimen Collection and Laboratory Methods

The participants were given a leaflet on how to collect a midstream clean-catch urine sample, and it was explained to them. Samples showing mixed growth of two or more organisms or growth of skin commensals without significant colony counts were considered contaminated and culture was repeated with second sample following education by healthcare staff. Those who failed to provide the second sample and had mixed growth in the second sample were excluded from the analysis.

Two midstream clean-catch urine specimens were obtained from each participant: one for culture on Cystine-Lactose-Electrolyte-Deficient (CLED) agar using a calibrated wire loop, and one for UFR microscopy. Significant bacteriuria was defined as growth of $\geq 10^5$ CFU/mL of a single organism; culture-positive specimens underwent antibiotic sensitivity testing using pregnancy-safe agents. Significant pyuria was defined as >10 white blood cells per high-power field (WBC/hpf). Women with positive cultures were contacted by telephone, recalled to clinic, and treated with a seven-day course of culture-guided antibiotics. A repeat urine culture one week after completing treatment confirmed microbiological cure (**Flow chart 1**).



Flow chart 1. Participant flow chart.

2.5. Risk Factor Assessment

Sociodemographic and obstetric data were collected at the booking visit using a structured interviewer-administered questionnaire. Variables assessed included age, parity, gestational age, socioeconomic status, educational level, prior history of UTI, presence of diabetes mellitus (DM), and sickle cell trait. Women in whom GDM investigation was pending at the time of recruitment were classified as "GDM status unknown" and were excluded from the risk-factor subgroup analysis for GDM specifically; they were retained in the overall cohort for prevalence estimation. This approach was adopted to avoid misclassification bias in the association analysis.

2.6. Statistical Analysis

Data were entered in Microsoft Excel. Continuous variables were assessed for normality using the Shapiro-Wilk test and summarized as mean ± standard deviation (SD) or median with interquartile range (IQR). Categorical variables were expressed as frequencies and percentages. Associations between ABU and potential risk factors were assessed using Fisher's exact two-tailed test when any cell count was <5, and chi-square with Monte Carlo p-values when comparing more than two categories. Statistical significance was set at a two-sided p-value of <0.05.

3. Results

3.1. Participant Characteristics

A total of 411 pregnant mothers were finally enrolled. The median age was 30 years (IQR: 7); mean 29.77 ± 5.46 years. The majority were multiparous (63.5%) and had booked in the second trimester (57.7%), with a median gestational age of 19 weeks at booking. Most participants had attained Ordinary or Advanced level education (35.5% and 38.4%, respectively), and 73.2% were housewives. The majority resided in urban areas (65.9%), with nearly half (49.9%) of households earning less than LKR 50,000 per month. Full sociodemographic details are presented in Table 1.

3.2. Clinical Risk Factors

Current GDM was diagnosed in 2.4% of participants; 45.5% had not yet been investigated for GDM. A prior history of GDM was reported by 1.0% and pre-existing type 2 diabetes by 0.5%. A history of any UTI was present in 11.9%, while only 0.5% reported a prior diagnosis of ABU specifically; none reported recurrent UTI. Hospital admission within the preceding three months was reported by 6.8%, recent antibiotic use within three months by 12.7%, and sexual activity during the current pregnancy by 49.1%.

3.3. Prevalence of ABU

Urine culture was positive in 12 of 411 participants, yielding a culture-confirmed ABU prevalence of 2.9% (95% CI: 1.5% - 5.0%). The remaining 399 women (97.1%) had no significant bacterial growth.

3.4. UFR Diagnostic Performance

Significant pyuria was identified in 71.6% of participants on UFR microscopy. Using pyuria as an index test for ABU: sensitivity was 100%, specificity 29.2%, positive predictive value (PPV) 4.1%, and negative predictive value (NPV) 100%. The high NPV confirms that absence of pyuria effectively excludes ABU. However, the poor specificity and low PPV mean that the vast majority of women with pyuria will have negative urine cultures.

Table 1. Sociodemographic characteristics of study participants (n = 411).

Characteristic	Frequency (n)	Percentage (%)
Maternal Age (years)		
Mean ± SD	29.77 ± 5.46	—
Median (IQR)	30 (7)	—
Parity		
Primiparous	150	36.5
Multiparous	261	63.5
Gestational Age at Booking		
First trimester	82	19.9
Second trimester	237	57.7
Third trimester	92	22.4
Maternal Education		
Illiterate	1	0.2
Primary/Secondary	31	7.6
Ordinary level	146	35.5
Advanced level	158	38.4
Higher education	75	18.2
Maternal Occupation		
Housewife	301	73.2
Employed	108	26.2
Student	2	0.5
Residential Area		
Urban	271	65.9
Rural	137	33.3
Estate	3	0.7

SD: Standard deviation; IQR: Interquartile range.

3.5. Causative Organisms

Staphylococci were the most frequently isolated organisms (5 isolates, 41.7%), followed by Streptococci (4 isolates, 33.3%) and Coliforms (3 isolates, 25.0%). Within the Streptococcal group, GBS was the most common species, accounting for 25% of all positive cultures. The full pathogen breakdown is presented in **Table 2**.

Table 2. Causative organisms isolated in culture-positive participants (n = 12).

Isolated Organism	n	%
Coliforms	3	25.0
Streptococci (total)	4	33.3
Group B Streptococcus	3	25.0
Enterococcus	1	8.3
Staphylococci (total)	5	41.7
Coagulase-negative Staphylococcus	2	16.7
Staphylococcus saprophyticus	2	16.7
Staphylococcus aureus	1	8.3
Total	12	100.0

3.6. Antibiotic Sensitivity, Treatment, and Outcomes

All five Staphylococcal isolates (100%) were sensitive to nitrofurantoin; four (80%) were also sensitive to cloxacillin. All four Streptococcal isolates (100%) were sensitive to ampicillin and were treated with oral amoxicillin. Among the three Coliform isolates, two were sensitive to nitrofurantoin and one to cefuroxime; one Coliform was resistant to both cephalosporins and nitrofurantoin and required gentamicin-level agents. Cephalosporin resistance was identified in two of three Coliform isolates (66.7%). On follow-up, 9 of 12 women (75%) were tested with repeat urine culture after treatment and achieved microbiological cure. 3 of 12 women (25%) defaulted follow-up and labelled as defaulters. Full details by organism are presented in Table 3.

Table 3. Antibiotic sensitivity, treatment prescribed, and follow-up outcomes by organism (n = 12).

Organism	Antibiotic Sensitivity	Treatment Given	Follow-up
Coliforms (n = 3)	Nitrofurantoin (n = 2); Cefuroxime (n = 1); Gentamicin/Amikacin/ Pip-Tazo/Meropenem (n = 1)	Nitrofurantoin (n = 1); Cefuroxime (n = 1); Amoxicillin (n = 1)	Negative culture: 3/3
Staphylococci (n = 5)	Nitrofurantoin (n = 5, 100%); Cloxacillin (n = 4, 80%)	Cloxacillin (n = 3); Nitrofurantoin (n = 2)	Negative: 3/5; Defaulted: 2/5
Streptococci (n = 4)	Ampicillin (n = 4, 100%)	Amoxicillin (n = 4)	Negative: 3/4; Defaulted: 1/4

Pip-Tazo: Piperacillin-tazobactam.

3.7. Statistical Associations with ABU

Statistically significant associations were identified between ABU and three variables: current GDM (OR = 13.13; p = 0.03), prior history of ABU (OR = 53.33; p = 0.04), and significant pyuria on UFR (OR → ∞; p = 0.04). No significant associations were found with parity, trimester at booking, maternal education, occupation, residential area, hospital admission, antibiotic use, past UTI history, sexual activity, previous vaginal delivery, or previous obstetric trauma. The complete statistical summary is presented in Table 4.

Table 4. Statistical associations between potential risk factors and ABU (n = 411).

Variable	Statistical Test	OR/χ^2	p-value	Significant
Parity (Primi vs Multi)	Fisher's exact	OR = 0.15	0.06	No
Trimester	Chi-square (MC)	χ^2 = 1.67	0.43	No
Maternal education	Chi-square (MC)	χ^2 = 3.15	0.21	No
Maternal occupation	Chi-square (MC)	χ^2 = 1.30	0.52	No
Residential area	Fisher's exact	OR = 0.72	0.55	No
Hospital admission (<3 months)	Fisher's exact	OR = 0.80	0.58	No
Antibiotic use (<3 months)	Fisher's exact	OR = 0.42	0.18	No
GDM (current pregnancy)	Fisher's exact	OR = 13.13	0.03	Yes
Past history of GDM	Fisher's exact	OR = 0.0	1.00	No
Pre-existing diabetes (T2DM)	Fisher's exact	OR = 0.0	1.00	No
Past history of UTI	Fisher's exact	OR = 1.50	0.64	No
Past history of ABU	Fisher's exact	OR = 53.33	0.04	Yes
Sexual activity during pregnancy	Fisher's exact	OR = 0.73	0.77	No
Previous vaginal delivery	Fisher's exact	OR = 3.31	0.14	No
Previous obstetric trauma	Fisher's exact	OR = 0.0	1.00	No
Significant pyuria (UFR)	Fisher's exact	OR → ∞	0.04	Yes

ABU: Asymptomatic bacteriuria; GDM: Gestational diabetes mellitus; UTI: Urinary tract infection; UFR: Urine full report; MC: Monte Carlo; OR: Odds ratio; Bold rows indicate statistically significant associations ($p < 0.05$).

4. Discussion

This study screened 411 pregnant mothers at Teaching Hospital Peradeniya and found a culture-confirmed ABU prevalence of 2.9%. This is considerably lower than those reported from many African and South Asian settings, where pooled prevalences from systematic reviews of Africa and India have been estimated at 11.1% and 13.5%, respectively [11] [12]. Individual studies from India have reported rates ranging from 12.3% in Udaipur [7] to 28% in Dhule [13], and rates from Pakistan, West Kenya, and Ethiopia have ranged between 15.6% and 19.2% [6] [14]-[17]. Our finding is broadly consistent with the 3.6% reported from Colombo in 2012 [3] and 3.4% from Saudi Arabia [18], suggesting genuine regional differences in hygiene, socioeconomic context, antenatal care quality, and population characteristics rather than methodological artefact.

The pathogen profile in our cohort was strikingly different from most global reports, where Escherichia coli typically predominates (33% - 54%) [11] [14] [15]

[19]. In our study, Staphylococci were the leading organism (41.7%), followed by Streptococci (33.3%), with Coliforms forming a minority (25.0%). This pattern more closely resembles findings from Saudi Arabia, where GBS was the second most isolated organism (23.8%) after E. coli [18]. The relatively high proportion of GBS (25% of all positive cultures) is clinically important given its well-established role in neonatal early-onset sepsis and meningitis; ABU screening affords an opportunity to identify GBS carriers and offer intrapartum antibiotic prophylaxis.

Nitrofurantoin performed consistently well against both Staphylococci and most Coliform isolates, reinforcing its role as a safe and effective first-line agent for ABU in pregnancy, as consistently supported by international literature [16] [20] [21]-[24]. The apparent under-utilization of nitrofurantoin at our centre—despite strong sensitivity data—mirrors the Colombo South experience [9] and likely reflects clinician and patient preference for alternatives with more convenient dosing schedules over the four-times-daily immediate-release regimen. Cephalosporin resistance in 66.7% of Coliform isolates aligns with global concerns about rising beta-lactam resistance and underscores the essential role of culture-guided prescribing [25] [26].

The diagnostic performance of UFR pyuria warrants careful interpretation. The 100% NPV means that absence of pyuria effectively excludes ABU, making UFR a useful triage tool to reduce unnecessary culture requests. However, the 4.1% PPV means the vast majority of women with pyuria have negative cultures; treating on the basis of pyuria alone would expose many pregnant women to unnecessary antibiotics, with attendant risks of side effects and resistance selection. This conforms to established diagnostic heuristics: a highly sensitive test rules out disease when negative, but a specific test is needed to rule it in [27]. Our findings therefore support using UFR as an initial screen only, with urine culture remaining the obligatory confirmatory test before treatment.

The three significant risk factors identified—current GDM, prior history of ABU, and significant pyuria—are each clinically coherent. GDM promotes glycosuria and impairs neutrophil function, creating a permissive environment for urinary colonization [20]. A prior diagnosis of ABU is a well-recognized predictor of recurrence. The failure to detect associations with traditionally cited risk factors (parity, prior UTI history, socioeconomic status) most likely reflects the limited statistical power arising from the small number of culture-positive cases (n = 12), rather than absence of true biological associations.

The 75% microbiological cure rate among women who completed follow-up reflects the efficacy of short-course culture-guided therapy. The three women who defaulted follow-up represent a clinically important gap, highlighting the need for proactive patient recall systems and clear communication regarding the importance of test-of-cure cultures.

Systematic review evidence suggests that treating confirmed bacteriuria in pregnancy lowers the risk of pyelonephritis and low birth weight, though the certainty of these estimates is low and evidence on the effectiveness of population screening programmes is very limited [28] [29].

Despite growing calls to limit unnecessary antimicrobial exposure and curb the broader overtreatment of asymptomatic bacteriuria in non-pregnant populations, pregnant women remain among the few groups for whom major international guidelines continue to endorse routine screening and treatment, given the demonstrated risk of progression to pyelonephritis and associated adverse pregnancy outcomes [30]. However, adherence to these guidelines in real-world clinical practice is inconsistent, highlighting a persistent gap between recommended and actual management that further reinforces the need for setting-specific data.

5. Limitations

This single-centre tertiary hospital study limits generalizability to peripheral antenatal units or private practice settings across Sri Lanka. The small number of culture-positive cases (n = 12) substantially limited statistical power for detecting risk factor associations and organism-level sensitivity estimates. Loss to follow-up in three cases may have biased cure rate calculations, and exclusion of mixed-growth cultures may have led to underestimation of the true infection burden. Self-reported risk factor data are susceptible to recall bias, particularly for sensitive information such as sexual history. Finally, UFR interpretation performed under routine clinical rather than standardized research conditions may have introduced interobserver variability in pyuria reporting.

6. Conclusions

This study found a relatively low prevalence of asymptomatic bacteriuria in pregnancy (2.9%) at Teaching Hospital Peradeniya, with a distinctive pathogen profile characterized by Staphylococcal predominance and a clinically significant proportion of Group B Streptococcus. Nitrofurantoin demonstrated reliable activity against Staphylococci and most Coliforms; amoxicillin was appropriate for Streptococcal infections. Cephalosporin resistance among Coliforms reinforces the need for culture-guided prescribing and continuous antimicrobial surveillance. UFR pyuria serves as a useful high-sensitivity screening tool but cannot replace urine culture for confirming ABU or guiding treatment decisions.

At least one routine culture-based urine screen in early pregnancy is recommended, with treatment tailored to local sensitivity patterns. Women with current GDM or a prior history of ABU warrant heightened vigilance. Larger multicentre studies across Sri Lanka are needed to validate these findings and inform national screening and treatment guidelines.

Ethical Approval

Ethical clearance was granted by the Ethics Review Committee, Faculty of Medicine, University of Peradeniya (Approval No. 2019/EC/78). Written informed consent was obtained from all participants. The study was conducted in accordance with the Declaration of Helsinki.

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Conflicts of Interest

The authors declare no conflicts of interest.

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