12-2020

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BMJ Open

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To cite: Kelly-Hanku A, Nightingale CE, Pham MD, *et al*. Loss to follow up of pregnant women with HIV and infant HIV outcomes in the prevention of maternal to child transmission of HIV programme in two high-burden provinces in Papua New Guinea: a retrospective clinical audit. *BMJ Open* 2020;**10**:e038311. doi:10.1136/bmjopen-2020-038311

► Prepublication history for this paper is available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2020-038311).

Received 09 March 2020
Revised 29 October 2020
Accepted 07 November 2020

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ABSTRACT

Introduction Despite early adoption of the WHO guidelines to deliver lifelong antiretroviral (ARV) regimen to pregnant women on HIV diagnosis, the HIV prevention of mother to child transmission programme in Papua New Guinea remains suboptimal. An unacceptable number of babies are infected with HIV and mothers not retained in treatment. This study aimed to describe the characteristics of this programme and to investigate the factors associated with programme performance outcomes.

Methods We conducted a retrospective analysis of clinical records of HIV-positive pregnant women at two hospitals providing prevention of mother to child transmission services. All women enrolled in the prevention of mother to child transmission programme during the study period (June 2012–June 2015) were eligible for inclusion. Using logistic regression, we examined the factors associated with maternal loss to follow-up (LTFU) before birth and before infant registration in a paediatric ARV programme.

Results 763 of women had records eligible for inclusion. Demographic and clinical differences existed between women at the two sites. Almost half (45.1%) of the women knew their HIV-positive status prior to the current pregnancy. Multivariate analysis showed that women more likely to be LTFU by the time of birth were younger (adjusted OR (AOR)=2.92, 95% CI 1.16 to 7.63), were newly diagnosed with HIV in the current/most recent pregnancy (AOR=3.50, 95% CI 1.62 to 7.59) and were in an HIV serodiscordant relationship (AOR=2.94, 95% CI 1.11 to 7.84). Factors associated with maternal LTFU before infant registration included being primipara at the time of enrolment (AOR=3.13, 95% CI 1.44 to 6.80) and being newly diagnosed in that current/most recent pregnancy (AOR=2.49, 95% CI 1.31 to 4.73). 6.6% (50 of 763) of exposed infants had a positive HIV DNA test.

Conclusions Our study highlighted predictors of LTFU among women. Understanding these correlates at different stages of the programme offers important insights for targets and timing of greater support for retention in care.

Strengths and limitations of this study

- This study used real-world data from the national HIV prevention of mother to child transmission programme in Papua New Guinea (PNG), providing data that reflect programme delivery in a routine setting.
- The study included over 700 clinical records, comprising the largest and most systematic evaluation of prevention of mother to child transmission programmes in PNG.
- The retrospective nature of the study made it reliant on the quality of data that had been collected, which in many cases were incomplete.
- Missing data limited the choice of data analysis approaches.
- Despite data limitations, this study provides important insights into the prevention of mother to child transmission programmes in PNG, and findings can be used to inform the development of effective interventions.

INTRODUCTION

Maternal early initiation and adherence to antiretroviral therapy (ART) during pregnancy and breast feeding and prophylactic administration of antiretrovirals (ARV) to infants exposed to HIV can reduce the risk of transmission to newborns from 30%–45% to less than 5%.[1–3] Through a combination of advancements in medicines, political commitment, multilateral funding and a dedicated

health workforce, many countries have now eliminated mother to child transmission of HIV.[4 5] Many settings have made significant progress in the implementation of the WHO-recommended Option B+ regimen, whereby all pregnant and breastfeeding women living with HIV are offered lifelong ART on diagnosis.[6] However, many countries which have adopted Option B+, including Papua New Guinea (PNG), continue to struggle in providing effective prevention of mother to child transmission programmes and in retaining mothers and infants in lifelong care and treatment.[7–9]

Supporting maternal adherence to ART and retaining mothers and infants in these treatment programmes are essential components in preventing mother to child transmission of HIV. Factors contributing to lower adherence and greater loss to follow-up (LTFU) from prevention of mother to child transmission programmes include concerns with lifelong treatment, inadequate counselling, lack of male partner involvement and support, fear of disclosure, knowing someone who has had a negative experience, and distance to the health facility.[10–15] Conversely, good-quality HIV post-test counselling, support from partners and family, belief in ART efficacy and being aware of the improved survival of other people have been reported as facilitators to initiation of ART, adherence and reduced LTFU from prevention of mother to child transmission programmes.[11 12 14–16]

PNG is an independent Western Pacific Island nation of more than eight million people living a largely subsistence livelihood in geographically challenging terrain. Roads poorly connect major centres, and where roads exist landslides, tribal fighting and lawlessness often restrict reliable and safe travel routes. The overall adult HIV prevalence (15–49 years) is 0.8%,[17] higher in urban areas, and substantially greater among key populations of female sex workers, men who have sex with men and transgender women.[18–20] Consistent with WHO recommendations, PNG's HIV treatment guidelines follow a test-and-treat model, including lifelong treatment for pregnant and breastfeeding women.[21] Despite the progressive approach, it is estimated that only half (55%; 26 400 of 48 000) of people living with HIV were receiving ART in 2017, and of the estimated 1700 pregnant women living with HIV only 41% received ART.[22] The need for improvements in the prevention of mother to child transmission programmes is further highlighted by the fact that the number of babies born with HIV doubled between 2017 and 2018.[23] What remains unknown is where and for which subpopulations the mother to child transmission programme is failing. Answers from national programmes could offer insight on where to target interventions to ensure women are not LTFU and to refocus and galvanise efforts to reduce neonatal infections to achieve the goal of eliminating mother to child transmission. We conducted a retrospective clinical audit at two antenatal clinics (ANC) in Goroka and Port Moresby in PNG to describe prevention of mother to child transmission programme characteristics and investigate factors associated with programme performance outcomes.

METHODS

Study settings

The two sites were selected as they were both in high-burden HIV provinces, were the longest running sites for prevention of mother to child transmission in the country, and were well supported through donor funding and non-governmental organisations, such as the Clinton Health Access Initiative. Port Moresby is the national capital city, on the southern coast of the country, and is a melting pot of people from across the country. It is one of only three cities in the country. Goroka is a town and the provincial capital of the Eastern Highlands Province, in the lower highlands region of the country. The geographical, sociocultural and economic contexts of these two sites are diverse. Unlike Port Moresby, Goroka is much smaller and people access the town from across the province, travelling by foot and road. Travel between these two sites is only possible by air. HIV testing is available at numerous ANC clinics in each province; however, there is only one prevention of mother to child transmission clinic in each province.

The implementation model for the prevention of mother to child transmission programme differed between the two sites. In Port Moresby, prevention of mother to child transmission services were integrated in antenatal, delivery and postnatal care services for the first 6 weeks. After the 6-week postnatal period, HIV-exposed infants were referred for enrolment in the paediatric HIV clinic for ongoing HIV prophylaxis, confirmatory HIV testing and treatment as required, while mothers were referred to the adult ART outpatient clinic. The adult and paediatric HIV clinics were not co-located and operated on different days, and clinical records were not linked manually or electronically. In Goroka, prevention of mother to child transmission services were integrated in antenatal, delivery and postnatal care, and the mother-infant pair is cared for by the same clinical team until the confirmatory HIV test for the infant was conducted at 18 months. Despite its co-location infants were still enrolled in the paediatric HIV clinic at 6 weeks. At 18 months after birth, the mother was transferred (back) to the adult ART clinic, while the HIV-infected infant/s remained in the clinic for ongoing clinical care and management. All healthcare was provided by staff who were employed as government healthcare workers or were supported and funded by the Clinton Health Access Initiative, funded by the Australian government.

Study participants and procedures

The clinical audit used a 'capture all' approach, documenting all women with HIV enrolled in the prevention of mother to child transmission programme for the 3-year time period spanning June 2012 (when Option B+ was

formally adopted in PNG) until June 2015. Data sources included paper-based antenatal records of HIV-positive women and their infants' medical records at either the same prevention of mother to child transmission clinic (Goroka) or the paediatric HIV clinic elsewhere in the hospital (Port Moresby).

For all available records, two research midwives manually extracted data related to patient demographics, pregnancy care, HIV and other sexually transmitted infection testing, prevention of mother to child transmission enrolment, ART initiation and clinic appointments, and these were recorded on preprinted study clinical research forms. Infants' HIV DNA test results were obtained from infant records. Infant records in Goroka were physically co-located with the mothers. In Port Moresby, mother-infant pairs were linked manually by extracting the name of the mother, the birth date of the infant on her ANC record, and if recorded the sex of the newborn. Staff at the paediatric HIV clinic then identified infant records to link the mother-infant pairs.

Research midwives cross-checked each other's completed data forms to ensure all forms were completed as accurately as possible. After reviewing each form for validity and completeness, de-identified data were double-entered into a purposely developed study database and stored on a password-protected computer at the Papua New Guinea Institute of Medical Research. All electronic data were merged into a single study database and analysed using STATA V.13.1.

Study measures and analysis

At enrolment into the prevention of mother to child transmission programme, sociodemographic, obstetric and HIV-related characteristics were recorded and laboratory assessments conducted. In our analysis we only included the first pregnancy when assessing maternal characteristics and outcomes. However, for infant characteristics and outcomes, all live births were included. LTFU was measured and defined at two timepoints. First, pregnant women enrolled in the prevention of mother to child transmission programme were categorised as 'lost to follow-up before delivery' if they did not return to the health facility for delivery, and could include scheduled antenatal prevention of mother to child transmission visits. Second, pregnant enrolled women in the prevention of mother to child transmission programme were defined as 'lost to follow-up before infant registration' if they did not register the newborn child at the respective clinics for prevention of mother to child transmission services and were lost from the programme either during antenatal, peripartum or early postnatal services. Although the study sponsor originally sought to have the audit measure maternal LTFU at 2 years after lifetime ART initiation in the prevention of mother to child transmission programme (Option B+), this was not possible. In PNG, paper-based adult ART records were used and there was no system that linked women in prevention from mother to child transmission programmes to adult ART service records. At the time the audit was undertaken, only two ART sites in Port Moresby were using an electronic database, which was manually updated into a national database by staff at the National Department of Health every few months. Enrolment of a child into paediatric HIV programmes shows ongoing engagement in HIV care. The fact that so many women did not enrol their children in these clinics shows disengagement. Like prevention of mother to child transmission programmes, there is only one paediatric HIV clinic in each province.

Descriptive analyses were conducted to describe the women enrolled in the prevention of mother to child transmission programmes at the sites and the HIV outcomes of their infants. χ^2 tests, two-sample t-tests and Wilcoxon rank-sum tests were performed to examine differences in sociodemographic and other behavioural characteristics of women and infants in the sites. Multivariate logistic regression analysis was undertaken to investigate factors associated with maternal LTFU before birth and the mean time before the infant was registered in a paediatric ART programme. Based on findings from previous research[24] and data available from this study, we selected variables that might influence the outcome of interest (maternal LTFU) to be included in the predictive models. For the analysis of factors associated with maternal LTFU before birth, we used Firth's logistic regression[25 26] to account for bias due to rare event data, which are known to produce substantial bias estimates with conventional logistic regression.[27] Assumption of rare event data was made based on few outcome events per variable (EPV) guideline with at least five EPV in models used for confounding adjustment.[28] Infant HIV testing and results were quantified and described.

Ethical considerations

This was a retrospective cohort study and women were no longer attending the ANC. Consent from the participating hospitals was granted to access clinical records on the condition that no identifiable information, including names, was recorded on the clinical research forms.

Patient and public involvement

We did not invite patient and public involvement in the design of the study due to the nature of the study, being a retrospective clinical audit commissioned by UNICEF. All study results were disseminated to stakeholders at the conclusion of the study.

RESULTS

Description of sample set

A total of 849 cases were identified and registered into the prevention of mother to child transmission programme across the two sites (figures 1 and 2). Eight women and their records were excluded as they described women who were not pregnant (n=4), not HIV-infected (n=3) or had been diagnosed through a sick child (n=1). Of the 841 remaining eligible pregnancies, 39 (4.6%) had missing

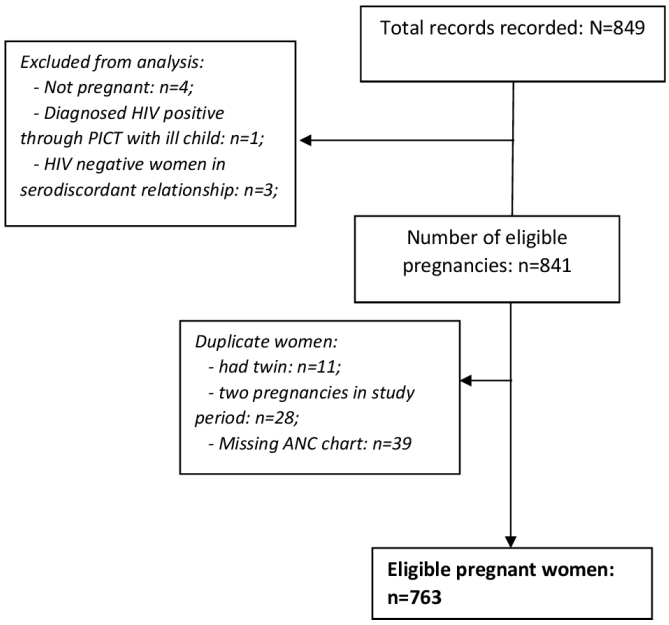

Figure 1 Flow diagram of eligible pregnant women. ANC, antenatal clinic.

ANC records, 11 records (1.3%) described women who had twins, and 28 women (3.3%) had two pregnancies in the study period and were therefore enrolled twice in the prevention of mother to child transmission programme in the period under investigation. The final analysed sample therefore described 763 eligible HIV-positive pregnant women (figure 1), which resulted in 763 live births and 30 stillbirths (figure 2). Not all records were complete. PNG uses paper-based records systems for prevention of mother to child transmission and paediatric HIV programmes that are not linked by a unique identification code or any other identifier. The challenges associated with linking mother-infant pairs resulted in some data not being available. The changing denominators in the table indicate where data were missing.

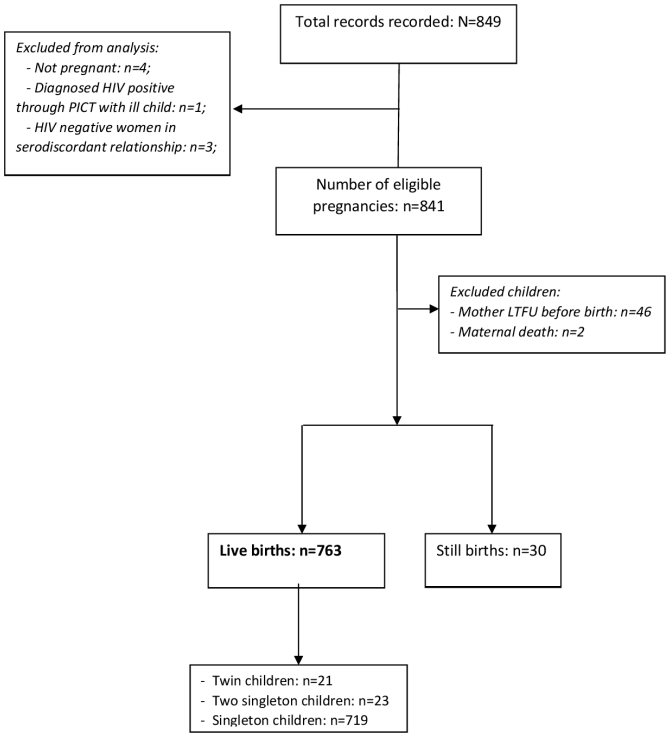

Figure 2 Flow diagram of eligible births. LTFU, loss to follow-up; PICT,Provider initiated counseling and testing.

Sociodemographic characteristics of enrolled women

One-third of the analysed records were from women registered at the Goroka prevention of mother to child transmission site and the other two-thirds from Port Moresby. The mean age of participants was 25 years at both sites. A greater proportion of women in Port Moresby were married (77.3% compared with 51.4%, p<0.001), had received any formal education (92.2% compared with 72.4%, p<0.001) and were employed in the formal sector (21.1% compared with 1.7%, p<0.001) than women in Goroka (table 1).

HIV and ART characteristics of enrolled women

Table 1 also details the HIV and ART characteristics of the population. Just over half (54.9%) of the cohort were newly diagnosed with HIV in their current pregnancy, with this proportion being greater in Port Moresby (57.9%) compared with Goroka (49.0%, p=0.020; table 2). In Goroka, women who already knew they were HIV-positive enrolled in the prevention of mother to child transmission programme earlier than those in Port Moresby (mean gestational weeks at enrolment 22.5 for Goroka and 26.1 for Port Moresby, p<0.001); however, timing of enrolment was not statistically different across the two sites for newly diagnosed women (table 2).

The median CD4 T cell count at enrolment into the programme was 327 cells/µL in Goroka, compared with 273 cells/µL in Port Moresby (p=0.005). More than 10% of all women were positive for antibodies to hepatitis B virus (13.7% in Goroka and 12.3% in Port Moresby, p=0.61).

Most (99.7%) of the women at both sites were receiving ART (table 2). Among those who already knew they were HIV-positive, most (91.3%) were taking ongoing treatment, with 8.7% recommencing treatment during the current pregnancy. While 100% of newly diagnosed women in Port Moresby were receiving ART, this was significantly lower among women in Goroka (92.4%, p<0.001).

Among women who were newly diagnosed, ART initiation was slower in Goroka with a median time between diagnosis and ART initiation of 14 days compared with 5 days in Port Moresby (p<0.001), and only 34.3% of women initiated treatment on the day of enrolment in the prevention of mother to child transmission programme in Goroka compared with 60.7% in Port Moresby (p<0.001). These delays translated to a higher proportion of newly diagnosed women receiving ART for less than 2 weeks before birth in Goroka (11.9%) compared with Port Moresby (6.1%, p=0.002).

Table 1 Sociodemographic, obstetric and HIV-related characteristics of 763 eligible women attending services in PNG

	All women (n=763) % (n/N)	Goroka (n=256) % (n/N)	Port Moresby (n=507) % (n/N)	P value
Mean age (SD), n=761	25.4 (5.05)	25.7 (5.4)	25.3 (4.9)	0.33
Marital status				<0.001
Married	68.5 (518/756)	51.4 (131/255)	77.3 (387/501)	
Married-polygamist	21.6 (163/756)	40.0 (102/255)	12.2 (61/501)	
Single/no partner/boyfriend only	8.1 (61/756)	6.3 (16/255)	9.0 (45/501)	
Widow	1.9 (14/756)	2.4 (6/255)	1.6 (8/501)	
Education				<0.001
No formal education	14.7 (107/730)	27.6 (70/254)	7.8 (34/476)	
Primary education only	41.0 (299/730)	42.5 (108/254)	40.1 (191/476)	
Secondary education only	36.6 (267/730)	24.8 (63/254)	42.9 (204/476)	
College/technical/vocational	6.4 (47/730)	4.7 (12/254)	7.4 (25/476)	
University	1.4 (10/730)	0.4 (1/254)	1.9 (9/476)	
Employment				<0.001
Informal sector	29.3 (204/696)	38.5 (89/231)	24.7 (115/465)	
Formal employment	14.7 (102/696)	1.7 (4/231)	21.1 (98/465)	
No paid work	54.6 (380/696)	58.9 (136/231)	52.5 (244/465)	
Student	1.4 (10/696)	0.9 (2/231)	1.7 (8/465)	
Region of origin				<0.001
Highlands Region	55.8 (415/744)	93.8 (240/256)	35.9 (175/488)	
Momase Region	5.1 (38/744)	4.3 (11/256)	5.5 (27/488)	
Southern Region, including NCD	36.6 (272/744)	1.2 (3/256)	55.1 (269/488)	
New Guinea Islands Region	2.6 (19/744)	0.8 (2/256)	3.5 (17/488)	
Parity				0.185
Nullipara	33.0 (250/758)	32.4 (83/256)	33.3 (167/502)	
Primipara	30.5 (231/758)	26.9 (69/256)	32.3 (162/502)	
Multipara	36.5 (277/758)	40.6 (104/256)	34.5 (173/502)	
Relationship HIV status				0.105
Concordant HIV positive	36.5 (248/679)	41.4 (106/256)	33.6 (142/423)	
Discordant HIV status	17.1 (116/679)	14.8 (38/256)	18.4 (78/423)	
Unknown status/no partner	46.4 (315/679)	43.8 (112/256)	48.0 (203/423)	
HIV status disclosure				<0.001
Yes	86.8 (524/604)	95.3 (221/232)	81.5 (330/372)	
Site of HIV testing				<0.001
ANC	55.4 (405/731)	49.4 (122/247)	58.5 (283/484)	
HIV/SH clinic/VCT centre	28.3 (207/731)	36.4 (90/247)	24.2 (117/484)	
Subdistrict health/aid post	2.9 (21/731)	8.5 (21/247)	–	
Other area of hospital	1.1 (8/731)	2.4 (6/247)	0.04 (2/484)	
Private health clinic	0.6 (4/731)	–	0.8 (4/484)	
Other	11.8 (86/731)	3.2 (8/247)	16.1 (78/484)	
HIV status at ANC visit				0.02
Known positive	45.1 (343/761)	51.0 (130/255)	42.1 (213/506)	
Newly diagnosed	54.9 (418/761)	49.0 (125/255)	57.9 (293/506)	
CD4+ count at enrolment, median (IQR)				

Continued

Table 1 Continued

	All women (n=763) % (n/N)	Goroka (n=256) % (n/N)	Port Moresby (n=507) % (n/N)	P value
All women	290.5 (193–409), n=650	327 (197–468), n=226	273 (190–384), n=424	0.005
Known HIV-positive women	349 (235–477), n=288	364 (234–504), n=123	341 (236–451), n=165	0.219
Newly diagnosed women	252.5 (176–360), n=362	279 (169–419), n=103	249 (179–341), n=259	0.154
Gestational age at enrolment, mean weeks (SD)				
All women (n=734)	26.1 (6.9)	25.2 (7.5)	26.6 (6.6)	0.01
Known HIV-positive (n=332)	24.7 (7.2)	22.5 (6.9)	26.1 (7.0)	<0.001
Newly diagnosed (n=402)	27.3 (6.6)	28.0 (7.1)	26.9 (6.3)	0.14
Hepatitis B status				
Positive	12.8 (77/602)	13.7 (30/219)	12.3 (47/383)	0.61
Syphilis status				
Positive	5.2 (23/441)	7.8 (17/218)	2.7 (6/223)	0.02

ANC, antenatal clinic; NCD, National Capital District; PNG, Papua New Guinea; SH, sexual health clinic; VCT, voluntary counselling and testing centre.

Infant follow-up and HIV test outcomes

There were a total of 763 live births from enrolled women (table 2). Almost 1 in 10 births in Goroka (9.8%) were non-facility births, defined as births outside a health facility, compared with 3.0% in Port Moresby (table 2). Almost all newborns (97%) in Port Moresby received ARV prophylaxis within 72 hours of birth, compared with only two-thirds of newborns in Goroka (67.5%). While there was no difference in the proportion of infants who had ever registered in a paediatric HIV programme, the rates of paediatric LTFU were much greater in Port Moresby (45.7%) compared with Goroka (23.2%, p<0.001). One in five infants (21.6%) were either not tested or had HIV DNA testing data missing, and 6.6% of tested babies returned a positive DNA test for HIV. Of these, only three-quarters were started on ART in the study period.

Maternal follow-up and factors associated with being LTFU

Of the 77 women (77 of 755, 10.2%) who were LTFU before they gave birth, we had sufficient programmatic data from 49 women (63.6%) for the multivariate analysis (table 3). Data were more complete for the Goroka site, with 72% (46 of 64) of those LTFU having sufficient data compared with only 23% (3 of 13) from Port Moresby (data not shown).

Women aged 16–20 years were almost three times more likely to be LTFU compared with those aged between 21 and 30 years when adjusted for other included variables (adjusted OR (AOR)=2.92, 95% CI 1.16 to 7.36). Women in an HIV serodiscordant relationship were three times more likely to be LTFU (AOR=2.94, 95% CI 1.11 to 7.84) compared with those in an HIV seroconcordant relationship, and women newly diagnosed during the current pregnancy were more than three times more likely to be LTFU before birth compared with women who already knew they were HIV-positive (AOR=3.50, 95% CI 1.62 to 7.59).

Of the 113 women (113 of 757, 14.9%) who were LTFU before infant registration, we had sufficient programmatic data from 61 women (54.0%) for the multivariate analysis (table 4). Again, completeness of data was higher for Goroka (64.5%) than for Port Moresby (50.0%). Primipara women, as compared with nullipara women, were significantly more likely to be LTFU before infant registration (AOR=3.13, 95% CI 1.44 to 6.80), as were women who were newly diagnosed in that current pregnancy (AOR=2.49, 95% CI 1.31 to 4.73).

DISCUSSION

In an attempt to quantify and explain maternal LTFU, this clinical audit was the first to systematically scrutinise the prevention of mother to child transmission programmes in PNG, providing much needed evidence to guide future programmatic efforts to improve outcomes for women and their children. Across two high case load and well-resourced sites, 1 in 10 of the women in this cohort were LTFU before they gave birth (n=77, 10.2%) and a further 36 women were LTFU after birth but prior to registering the infant in the paediatric HIV programme (n=113, 14.9%). More than 20% of HIV-exposed infants registered had no HIV testing data available, and of those who had a DNA test at 18 months of age or older more than 6% tested positive for HIV.

More than half of the women in the cohort already knew their positive HIV status, some having engaged in the

Table 2 Time on antiretroviral therapy and on prevention of mother to child transmission programmes, and delivery and follow-up characteristics of mothers and infants attending prevention of mother to child transmission programmes in PNG

	All women % (n/N)	Goroka % (n/N)	Port Moresby % (n/N)	P value
Mother variables (n=763 eligible pregnant women; 256 from Goroka and 507 from Port Moresby)				
Known positive women on ART				0.212
Total	99.7 (323/324)	99.1 (112/113)	100.0 (211/211)	
Ongoing treatment	91.3 (294/322)	93.7 (104/111)	90.1 (190/211)	
Recommenced in pregnancy	8.7 (28/322)	6.3 (7/111)	10.0 (21/211)	
Newly diagnosed women on ART	97.8 (399/408)	92.4 (109/118)	100.0 (290/290)	<0.001
Timing of ART initiation for newly diagnosed women				0.002
≥2 weeks before delivery	91.6 (349/381)	85.2 (86/101)	93.9 (263/280)	
<2 weeks before delivery	7.6 (29/381)	11.9 (12/101)	6.1 (17/280)	
After delivery	0.8 (3/381)	3.0 (3/101)	0.0 (0/280)	
Delay between diagnosis and ART initiation for newly diagnosed women, median days (IQR, range)	7 days (1–21, 0–532) n=396	14 days (1–29, 0–532) n=106	5 days (0–16, 0–161) n=290	<0.001
Timing of ART initiation relative to PMTCT enrolment for newly diagnosed women				<0.001
Before enrolment	6.0 (24/392)	0.9 (1/108)	7.9 (23/290)	
On day of enrolment	53.5 (213/398)	34.3 (37/108)	60.7 (176/290)	
<1 week of enrolment	15.1 (60/398)	17.6 (19/108)	14.1 (41/290)	
>1 week of enrolment	25.4 (101/398)	47.2 (51/108)	17.2 (50/290)	
Duration of care from enrolment to delivery, median days (IQR)	86 days (50–121) n=718	94 days (53–136) n=230	81 days (49–114) n=488	0.018
Duration of ART before delivery, median days (IQR)				
Newly diagnosed women	71 (36–103)	57 (26–85)	75 (42–106)	<0.001
	n=381	n=101	n=280	
Known positive women recommencing	108 (37–987)	167 (41–819)	104 (24–1126)	0.914
	n=49	n=15	n=34	
Known positive women on ART	887 (431–1636)	949 (500–1595)	866 (379–1690)	0.616
	n=261	n=92	n=169	
LTFU before delivery				<0.001
Yes	10.2 (77/755)	25.5 (64/251)	2.6 (13/504)	
No	88.7 (670/755)	71.3 (179/251)	97.4 (491/504)	
Deceased	1.1 (8/755)	3.2 (8/251)	0.0 (0/504)	
LTFU before infant registration				0.007
Infant death	3.4 (27/757)	6.4 (16/252)	2.6 (11/505)	
LTFU	14.9 (113/757)	12.3 (31/252)	16.2 (82/505)	
In follow-up	81.5 (617/757)	81.4 (205/252)	81.6 (412/505)	
Delivery details				<0.001
Supervised delivery	591/763 (77.5)	129/256 (50.4)	91.1 (462/507)	
Unsupervised delivery	40/763 (5.2)	25/256 (9.8)	3.0 (15/507)	
Data not available	132/763 (17.3)	102/256 (39.8)	5.9 (30/507)	
Infant variables (n=763 live births; 251 from Goroka and 512 from Port Moresby)				

Continued

Table 2 Continued

	All women % (n/N)	Goroka % (n/N)	Port Moresby % (n/N)	P value
Birth outcomes (n=793)				0.001
Live births	96.2 (763/793)	93.0 (251/270)	97.9 (512/523)	
Stillbirths	3.8 (30/793)	7.0 (19/270)	2.1 (11/523)	
Proportion of infants who were given ARV prophylaxis within 72 hours of birth	91.3 (564/618)	67.5 (81/120)	97.0 (483/498)	<0.001
Proportion of infants ever registered in a paediatric HIV programme	87.2 (663/760)	92.3 (229/248)	84.8 (434/512)	0.16
Proportion of infants tested for HIV at least once during follow-up				0.081
Tested positive	6.6 (50/763)	6.0 (15/251)	6.8 (35/512)	
Tested negative	71.8 (548/763)	76.9 (193/251)	69.3 (355/512)	
Never tested/data not available/LTFU/infant death	21.6 (165/763)	17.1 (43/251)	23.8 (122/512)	
Proportion of HIV-positive infants started on ART	74.0 (37/50)	80.0 (12/15)	71.4 (25/35)	0.527

ART, antiretroviral therapy; ARV, antiretroviral; LTFU, lost to follow-up; PMTCT, prevention of mother to child transmission; PNG, Papua New Guinea.

prevention of mother to child transmission programme for previous pregnancies. However, almost half the women enrolled were newly diagnosed with HIV in the current pregnancy. Consistent with findings from other settings, women who were newly diagnosed were more likely to be LTFU before they gave birth and/or before infant registration compared with women who already knew they were living with HIV.[9 29] This further emphasises the need for strengthened support and counselling at the point of entry into the prevention of mother to child transmission programme and when prescribing lifetime ART for newly diagnosed women. Likewise, younger women were more likely to be LTFU before delivery, indicating greater support may need to be directed to this population. Differentiated HIV support is necessary; the potential role of other women currently pregnant but who were already living with HIV and on lifetime ART should not be overlooked. The implementation of improved programmes to increase HIV testing rates among women of childbearing age, including strengthening male involvement in ANC, would also help to mitigate the chances of first becoming aware of an HIV-positive status during pregnancy and improve uptake of prevention of mother to child transmission services.[30] It is not surprising that knowledge of an HIV-positive status prior to pregnancy is associated with increased adherence to ART.[14 29 31] This audit also demonstrated that women who were primiparous were more likely to be LTFU before infant registration. While the factors influencing this finding remain unknown, it does speak to the need to target particular intervention approaches at the populations that they are most needed.

Although prevention of mother to child transmission programmes have received considerable research attention, recent systematic reviews on effective interventions highlight that quality evidence is still lacking to guide intervention design in improving uptake of ART and retention in programmes among mothers and their infants.[32 33] Success along the HIV care cascade has been achieved with comprehensive approaches. Using a comprehensive integrated approach involving point-of-care CD4 testing, integrated services and male community champions, a study in Nigeria demonstrated that mothers with access to comprehensively integrated system were more than three times likely to initiate ART and were more likely to be retained in care at 6 and 12 weeks post partum compared with mothers receiving usual care.[34] More modest success in improving maternal enrolment in HIV care, maternal ART initiation and infant testing rates is achieved through less complex integration models, with many of these models of HIV care not in and of themselves necessarily leading to better retention in HIV care and prevention programmes at 6 weeks post partum.[33 35] Therefore, co-location of maternal and child HIV care and treatment programmes does not automatically lead to better HIV care and treatment outcomes,[36] as our analysis shows. In our audit, LTFU rates for mothers before delivery were greater from the Goroka site which had co-located adult ART and prevention of mother to child transmission services. A multitude of factors previously reported to negatively impact retention in programmes, including long distances to the clinic,[10 37] long wait times and lower educational attainment,[38] are all relevant to women enrolled in Goroka and are all likely to contribute to LTFU, and these factors should be assessed and intervention approaches designed to mitigate their impact. Again, differentiated HIV care is important in prevention of mother to child transmission programmes, not just among newly diagnosed mothers but across the country, as women's sociocultural status is varied, in some respects significantly. For example, levels of education differ

Table 3 Factors associated with enrolled mothers being lost to follow-up before they delivered their infants (n=500)

	Frequency n/N (%)	Crude OR (95% CI)	Adjusted OR (95% CI)	P value
Site				<0.001
Port Moresby	3/303 (1.0)	1.0	1.0	
Goroka	46/197 (23.4)	30.46 (8.52 to 109.0)	39.7 (11.7 to 134.8)	
Age group				
16–20 years	19/82 (23.2)	3.80 (1.97 to 7.32)	2.92 (1.16 to 7.36)	0.023
21–30 years	25/340 (7.4)	1.0	1.0	
31–48 years	5/78 (6.4)	0.86 (0.32 to 2.33)	0.90 (0.29 to 2.73)	0.855
Marital status				
Married	24/335 (7.2)	1.0	1.0	
Married-polygamist	22/125 (17.6)	2.77 (1.48 to 5.19)	0.69 (0.31 to 1.53)	0.360
Single/widow/no partner/boyfriend only	3/40 (7.5)	1.05 (0.30 to 3.66)	0.62 (0.14 to 2.68)	0.523
Education				
No formal education	14/79 (17.7)	1.0	1.0	
Primary education	20/203 (9.9)	0.51 (0.24 to 1.07)	0.78 (0.33 to 1.84)	0.567
Secondary or more	15/218 (6.9)	0.34 (0.16 to 0.76)	0.66 (0.26 to 1.69)	0.389
Employment				0.400
Formal or informal sector	19/228 (8.3)	1.0	1.0	
No paid work or student	30/272 (11.0)	1.36 (0.74 to 2.50)	0.73 (0.34 to 1.53)	
Parity at enrolment				
Nullipara	26/153 (17.0)	1.0	1.0	
Primipara	10/153 (6.5)	0.34 (0.16 to 0.74)	0.74 (0.28 to 1.95)	0.539
Multipara	13/194 (6.7)	0.35 (0.17 to 0.72)	0.58 (0.21 to 1.62)	0.301
Relationship HIV status				
Concordant HIV positive	12/212 (5.7)	1.0	1.0	
Discordant HIV status	12/94 (12.8)	2.44 (1.04 to 5.70)	2.94 (1.11 to 7.84)	0.030
Unknown or no partner	25/194 (12.9)	2.47 (1.19 to 5.09)	1.82 (0.77 to 4.34)	0.173
HIV status disclosure				
Yes	44/444 (9.9)	1.0	1.0	
No	5/56 (8.9)	0.89 (0.34 to 2.35)	1.57 (0.41 to 5.99)	0.505
HIV status at ANC visit				
Known positive	12/273 (4.4)	1.0	1.0	
Newly diagnosed	37/227 (16.3)	4.24 (2.12 to 8.46)	3.50 (1.62 to 7.59)	0.001

ANC, antenatal clinic.

greatly, as does the prevalence of polygamous unions where there are multiple wives.

Many intervention approaches targeting individual behaviour have demonstrated potential in achieving better outcomes for mothers and infants. The use of phone calls and SMS (short message service)-based interventions can lead to improved maternal attendance, improved infant testing rates and improved retention at 6 weeks.[33 39] Phone-based interventions have not been trialled in PNG, and it is questionable whether this approach would be acceptable considering the remaining stigma of being HIV-positive and the rates of non-disclosure in the community. In addition to this, the high turnover of mobile phones and numbers could make using this system problematic.

Previous work in other low-income settings has demonstrated that conditional cash transfers had a positive impact on maternal attendance and retention,[40] and home visits by community-based health workers have resulted in higher proportions of infants breast feeding and attending clinics within the first week of their life.[41] As PNG moves forward to improve the prevention of mother to child transmission programmes across the country, this may well be an approach that should be piloted.

Table 4 Factors associated with enrolled mothers being lost to follow-up before infant registration (n=491)

	Frequency n/N (%)	Crude OR (95% CI)	Adjusted OR (95% CI)	P value
Site				
Port Moresby	41/299 (13.7)	1.0	1.0	
Goroka	20/192 (10.4)	0.73 (0.41 to 1.29)	0.60 (0.30 to 1.18)	0.139
Age group				
16–20 years	15/81 (18.5)	1.0	1.0	
21–30 years	42/334 (12.6)	0.63 (0.33 to 1.21)	0.63 (0.29 to 1.38)	0.246
31–48 years	4/76 (5.3)	0.24 (0.08 to 0.80)	0.32 (0.08 to 1.22)	0.095
Marital status				
Married	35/330 (10.6)	1.0	1.0	
Married-polygamist	19/120 (15.8)	1.59 (0.87 to 2.90)	1.67 (0.83 to 3.37)	0.150
Single/widow/no partner/boyfriend only	7/41 (17.1)	1.74 (0.71 to 4.22)	1.87 (0.70 to 5.00)	0.212
Education				
No formal education	11/76 (14.5)	1.0	1.0	
Primary education	33/202 (16.3)	1.15 (0.55 to 2.42)	0.92 (0.41 to 2.08)	0.849
Secondary or more	17/213 (8.0)	0.51 (0.23 to 1.16)	0.42 (0.17 to 1.02)	0.056
Employment				
Formal or informal sector	22/223 (9.9)	1.0	1.0	
No paid work or student	39/268 (14.6)	1.56 (0.89 to 2.72)	1.40 (0.76 to 2.57)	0.277
Parity at enrolment				
Nullipara	19/150 (12.7)	1.0	1.0	
Primipara	26/148 (17.6)	1.47 (0.77 to 2.80)	3.13 (1.44 to 6.80)	0.004
Multipara	16/193 (8.3)	0.62 (0.31 to 1.26)	1.48 (0.61 to 3.57)	0.384
Relationship HIV status				
Concordant HIV positive	17/213 (8.0)	1.0	1.0	
Discordant HIV status	12/94 (12.8)	1.69 (0.77 to 3.70)	1.70 (0.74 to 3.91)	0.215
Unknown or no partner	32/184 (17.4)	2.43 (1.29 to 4.57)	1.47 (0.69 to 3.16)	0.318
HIV status disclosure				
Yes	47/436 (10.8)	1.0	1.0	
No	14/55 (25.5)	2.83 (1.42 to 5.61)	1.64 (0.70 to 3.80)	0.252
Knowledge of HIV status				
Known positive	21/269 (7.8)	1.0	1.0	
Newly diagnosed	40/222 (18.0)	2.60 (1.47 to 4.59)	2.49 (1.31 to 4.73)	0.005

In this audit, LTFU before delivery was more likely among women who were living in an HIV discordant relationship, and addressing this factor is likely to involve greater male involvement in HIV care for women of childbearing age. Globally, there has been a focus on increasing male involvement in ANC, particularly in the context of prevention of mother to child transmission programmes. A number of diverse approaches have been used and show promising outcomes. For example, involving men can result in improved outcomes, including increased HIV testing in men, improved HIV-free survival of infants, increased HIV disclosure between partners and improved maternal adherence to care.[42] In PNG male involvement remains limited and is constrained by many factors. These include persistent cultural beliefs that issues of pregnancy and childbirth are for women only, long waiting times at ANC clinics, and financial barriers, including loss of daily wage (or equivalent in subsistence farming and marketing) to attend ANC and the additional cost for transport. In order to improve male involvement and see if this approach would benefit women and children, substantial work needs to go into addressing the deeply engrained sociocultural and health service barriers.[43]

While the rates of LTFU found here are comparative with other settings with similar resources,[7] what is of concern to the programme in PNG is how late women are enrolling in their pregnancies and their advanced HIV disease status, as evidenced by their low CD4 counts,

particularly for newly diagnosed women. At the time of this work and today in PNG, pregnant women with HIV are not offered HIV viral load testing; they are not a population eligible for such testing in the approved testing algorithm, and therefore we cannot examine what, if any, HIV viral load plays in LTFU. Further to this is the recorded delays between diagnosis and treatment initiation, resulting in less time on ART prior to birth to sufficiently reduce the viral load and reduce the risk of mother to child transmission. These delays are important to highlight as they offer obvious targets for programme improvement to reduce viral load. Yet the other issue is real: pregnant women who initiate treatment the day that they are diagnosed have been shown to be significantly less adherent than newly diagnosed pregnant women whose treatment is delayed.[44]

Essential to reducing and eliminating paediatric infections, the coverage of timely ARV prophylaxis for infants exposed to HIV must be resolved. In the period of this study, one-third (39 of 120, 32.5%) of infants in Goroka were not administered ARV prophylaxis within 72 hours of birth. This figure may, in part, be due to the high number of non-facility-based births, where mothers may have been unable or unwilling to present to the prevention of mother to child transmission clinic with their newborns within 72 hours of birth. Improving counselling around the importance of this prophylaxis, decentralising ARV prophylaxis to lower health centres where women give birth, encouraging supervised and facility-based births, and providing the necessary financial and logistic means to do so are interventions that warrant investigation.

Not only was the known HIV positivity rate among infants exposed to HIV greater than it should be with an effective prevention of mother to child transmission programme, HIV DNA testing rates were also suboptimal, with more than 20% of infants having no evidence of an HIV DNA test. These figures do not speak to effective programme implementation and provide evidence of high LTFU and failure of the health system to reach HIV-exposed infants with prevention of mother to child transmission services. These key infant measures highlight the real and urgent need for programmes to reduce infant LTFU to be adequately resourced and processes facilitating early infant diagnosis to be strengthened as a matter of urgency. Since this audit, no new programmes or resources have been put towards the national prevention of mother to child transmission programme, so these issues are likely to remain ever present, as highlighted and reinforced at the PNG HIV summit that called for a revitalisation amid expansion of the prevention of mother to child transmission programme to reduce transmission.[45] Noting that, in 2017, 150 children were diagnosed with HIV, a figure that doubled to 300 in 2018, the report notes that 'new-born children in PNG are at dangerously increased risk of acquiring HIV'. Thus, although this audit reflects years prior to this statement, the report shows that the findings and issues raised by the audit are current.

Limitations

In retrospective studies using routine data there are often data challenges, with missing data precluding the inclusion of some women who were LTFU in the multivariate analysis. We were challenged by the paper-based system for this reason as well as the use of non-standardised forms, both of which resulted in incomplete and inconsistent recording of patients' medical histories. Paper-based systems and the requirement to manually identify and link mother and infant records resulted in a significant delay to data collection and therefore strategic information to inform practice and policy. A computerised database that can link women in prevention of mother to child programmes to their children in paediatric HIV services and their records in adult HIV services would be a significant advancement for monitoring individual patient outcomes as well as national data on programme performance. The retrospective analysis also precluded us from gathering any further information from women who were LTFU on what barriers to remaining in care they experienced. These qualitative enquiries would further inform programme strengthening.

CONCLUSIONS

There is an urgent need for PNG to invest in its prevention of mother to child transmission programmes. In its current state, as we have shown, an unacceptably high proportion of women and their infants are LTFU, with other poor indicators including delays in ART initiation, number of stillbirths, delayed infant prophylaxis, high transmission rates and suboptimal testing rates. Women within the programme need to be more strongly supported to prevent LTFU and improve outcomes. With the current programme, the goal of the elimination of prevention of mother to child transmission will remain elusive and the health and well-being of women living with HIV and their children suboptimal.

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Funding The study was funded by UNICEF PNG.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

Ethics approval Ethical approval was granted by the PNG National Department of Health Medical Research Advisory Committee, the PNG National AIDS Council Secretariat's Research Advisory Committee, the PNG Institute of Medical Research's Institutional Review Board, and the Human Research Ethics Committee, UNSW Sydney.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplementary information. The ethics approval does not cover the provision of primary data to third parties.

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