

Supplemental Content

Maternal Health Services at Mae Tao Clinic

Maternal and reproductive health services are provided through Mae Tao Clinic's Reproductive Health Program, with the stated goal to "keep mothers strong and give all children a healthy start". The MTC Reproductive Health Department's inpatient and outpatient sections provide comprehensive women's services including family planning, gynecology, normal and complicated labor and delivery, neonatal care, and post-abortion care. Today the Reproductive Health Inpatient Department is located within Mae Tao Clinic's new compound, and includes 52 beds as well as short-term accommodation for those travelling far to seek services.

The antenatal care visits tracked in this study followed a standard protocol. All mothers receive counselling, prenatal laboratory screening (including blood group, hemoglobin, malaria, HIV, VDRL, urine), ultrasound investigation, immunization, prophylactic antihelminth treatment and dietary supplements (including iron, folic acid and vitamin B). Antenatal care visits are also a major touchpoint of care for pregnant mothers with HIV. HIV screening is provided during the first visit of antenatal care (ANC) and every pregnant woman who comes for delivery but did not attend ANC. A program for prevention of mother-to-child transmission of HIV (PMTCT) was also in place during the study period, which included anti-retroviral treatment, prophylaxis against infections, free laboratory investigations, delivery in a safe environment, milk formula and follow-up after birth.

The family planning visits tracked in this study included counselling on pregnancy risk factors and strategies for maintaining health during future pregnancy. Mothers attending these sessions were also offered emergency, short, and long-acting reversible contraception options. Most women preferred injections, which require a visit to the clinic every three months. During the last few years of the study period, MTC's reproductive health teams advocated for increased use of LARC (long-acting reversible contraception), such as implants or intrauterine devices (IUDs).

Mae Tao Clinic's Health Information System

The clinic's Health Information System (HIS) was constructed in 2007, and since then has tracked care delivery and patient outcomes across its 22 departments. Paper medical records are used by CHWs at the point of care, and relevant information is digitally transcribed by a dedicated HIS team at regular intervals. First-time patients of MTC are given a Registration Number that allows their information to be tracked across multiple visits and different departments.

MTC's HIS serves many critical functions. Key epidemiological indicators are used for cross-border disease surveillance and collaboration with public health departments at the regional and national level. The system also supplies information for MTC's monthly and annual reports that support donor outreach efforts, grant reporting requirements, and patient advocacy efforts. Pertinent information is also shared with local healthcare partners, such as Mae Sot General Hospital, and other Ethnic Health Organizations (EHOs) as part of the ongoing health-system strengthening initiatives. Internally, the system's data are used for quality improvement and resource allocation. Prior to this study, the entirety of the HIS's reproductive health data had never been aggregated across years and departments for supporting comprehensive retrospective analyses. The system contains over 34,000 deliveries, 135,000 antenatal care visits, and 70,000 family planning visits.

Unfortunately, MTC's HIS does not communicate with health data systems maintained by other providers in the region. Lack of integration between the disparate health organizations serving the border region's refugee and migrant population, among them MTC, Ethnic Health Organizations, regional health departments such as the Karen Department of Health and Welfare (KDHW), independent organizations such as Shoklo Malaria Research Unit, and hospitals such as Myawaddy Hospital in nearby Myawaddy, represents a critical barrier to integrated investigation of care and outcomes in the region. As the region's largest provider of reproductive healthcare for migrants and refugees, MTC likely represents the most viable setting for population-level maternal and child health research in the border region at present.

Temporal Analysis

Context

Political developments during the study period are essential for understanding the dynamics driving access to care, service utilization, and ultimately delivery outcomes. In particular, political developments in 2012 loosened restrictions on cross-border travel and improved access to care in Eastern Myanmar. This critical turning point for the region coincided with a bilateral cease fire agreement between the Karen National Union (KNU) and Burmese military. The increased political stability and safety in region made possible the launch of new primary health care facilities in 4 nearby townships of Karen State in 2014, expanding access to care across the border. The post-2012 period also saw the emergence of reinvigorated collaboration between the border region's consortium of EHOs, including MTC, Burma Medical Association (BMA), and the mobile Backpack Health Worker Team (BPHWT) among others. The ongoing focus on ethnic health system strengthening during this time led to widespread increases in access to maternal child health services and obstetrics care for migrant and refugee mothers on both sides of the border. Disparities between the pre- and post-2012 periods not only lend insight into the health impacts of regional politics, but also allow us to evaluate trends in outcomes that co-occurred with community-led efforts to strengthen the region's ethnic health system.

Methods

First, the number of deliveries per year was plotted to determine the overall trend in delivery caseload during the study period. Next, all independent variables, as well as prevalence of low birthweight delivery, were aggregated by year to assess for any overarching temporal trends during the study period. The Mann-Kendell test (a non-parametric statistical test for monotonic temporal trend) was performed on each variable's yearly time series to determine existence and statistical significance of any such trends ($\alpha = 0.05$). Additionally, deliveries were segregated based on admission date before and after the start of 2012, to assess for any broad-level changes following political changes that year which expanded cross-border health service access for migrants. A bivariate analysis of all variables pre- and post-2012 was conducted, following the same specifications noted above.

Results

The number of deliveries at MTC peaked in 2012 with 3564 deliveries, and has steadily declined since then, with 1318 deliveries in the final study year of 2019 [Figure 5]. Yearly low birthweight prevalence revealed clear downward trend over the study period, with a high of 15.8% in 2008 and low of 9.4% in 2018 [Figure 4]. Mann-Kendall modelling confirmed this trend in low birthweight delivery ($\tau = -0.727$, $\alpha = 0.001$), and also revealed trends towards increased utilization of first trimester ANC visits ($\tau = 0.795$, $p < 0.001$), second trimester visits ($\tau = 0.487$, $p = 0.024$), and family planning services ($\tau = 0.939$, $p < 0.001$). Rates of prior miscarriage fell during the study period ($\tau = -0.606$, $p < 0.001$) while the proportion of Karen ($\tau = 0.909$, $p < 0.001$) and Burmese ($\tau = 0.455$, $p = 0.047$) mothers as well as those over the age of 35 ($\tau = 0.545$, $p = 0.016$) increased. No significant changes in age were noted during the study period. Bivariate analysis of deliveries pre- and post-2012 corroborated these trends, revealing numerous statistically significant results across all independent variables [Table 4]. Notably, the average number of first trimester ANC and second trimester ANC visits were both higher in the post-2012 period, while the proportion of mothers accessing family planning services more than doubled (18% vs 8.8%, $p < 0.001$).

Comments

While prevalence of low birthweight within the cohort declined, access to ANC visits and utilization increased only modestly over the course of the study period. The mothers who delivered following 2012 did not attend, on average, even a single extra ANC visit during the first or second trimesters. Trends like this suggest underlying confounding relationships driven by geopolitical changes in the region. Key developments include opening of borders in 2012 making it easier for mothers to access care in eastern Burma, as well as overall health system strengthening shifting some burden of providing reproductive healthcare away from Mae Tao Clinic towards other region ethnic health organizations. These modest increases in care utilization among mothers delivering at MTC provide further motivation for re-examining the persistent barriers to care among displaced mothers in the region. Expansion of access in eastern Myanmar following 2012 may also have led fewer migrant and displaced mothers to cross the border to obtain care at MTC, offering one potential explanation for the decrease in deliveries since 2012.

Table S1. Bivariate analysis of dataset, separating deliveries before and after 2012. All variables displayed variation pre- and post-2012. Although difficult to know with certainty, political developments in the region likely contribute to such temporal trends present in the dataset.

	Overall ¹ n = 30,209	Before 2012 ¹ n = 14,071	After 2012 ¹ n = 16,138	p-value ²	q-value ³
Ethnicity				<0.001	<0.001
Burmese	19,278 (64%)	8,178 (58%)	11,100 (69%)		
Karen	4,566 (15%)	1,757 (12%)	2,809 (17%)		
Mon	436 (1.4%)	206 (1.5%)	230 (1.4%)		
Other	5,929 (20%)	3,930 (28%)	1,999 (12%)		
Age				<0.001	<0.001
< 20 years	2,552 (8.4%)	1,414 (10%)	1,138 (7.1%)		
20 – 35 years	23,387 (77%)	10,847 (77%)	12,540 (78%)		
> 35 years	4,270 (14%)	1,810 (13%)	2,460 (15%)		
Gravida					
Nulligravida	12,702 (42%)	5,997 (42%)	6,705 (41%)		
1	7,477 (25%)	3,358 (24%)	4,119 (26%)		
2	4,389 (15%)	2,039 (14%)	2,350 (15%)		
3	2,529 (8.4%)	1,173 (8.3%)	1,356 (8.4%)		
4+	3,112 (10%)	1,504 (11%)	1,608 (10%)		
Prior Miscarriage				<0.001	<0.001
No	24,798 (82%)	11,316 (81%)	13,437 (83%)		
Yes	5,411 (18%)	2,710 (19%)	2,701 (17%)		
Family Planning Visit				<0.001	<0.001
No	26,022 (86%)	12,834 (91%)	13,188 (82%)		
Yes	4,187 (14%)	1,237 (8.8%)	2,950 (18%)		
Number of 1st Trimester ANC Visits					
0	24,044 (80%)	11,501 (82%)	12,543 (78%)		
1	3,985 (13%)	1,727 (12%)	2,258 (14%)		
2	1,594 (5.3%)	631 (4.5%)	963 (6.0%)		
3+	586 (2.0%)	212 (1.5%)	374 (2.3%)		
Number of 2nd Trimester ANC Visits					
0	15,918 (53%)	7,399 (53%)	8,519 (53%)		
1	7,283 (24%)	3,468 (25%)	3,815 (24%)		
2	5,085 (17%)	2,424 (17%)	2,661 (16%)		
3+	1,923 (6.4%)	780 (5.5%)	1,143 (7.1%)		
Number of 3rd Trimester ANC Visits					
0	10,586 (35%)	4,650 (33%)	5,936 (37%)		
1	9,691 (32%)	4,699 (33%)	4,992 (31%)		
2	6,468 (21%)	3,209 (23%)	3,259 (20%)		
3+	3,464 (11%)	1,513 (11%)	1,951 (12%)		
Birthweight				<0.001	<0.001
Normal Birthweight	26,415 (87%)	12,109 (86%)	14,306 (89%)		
Low Birthweight	3,794 (13%)	1,962 (14%)	1,832 (11%)		

¹ Statistics presented: n (%), mean (standard deviation)

² Statistical tests performed: chi-square test of independence

³ False discovery rate correction for multiple testing

Table S2. Bivariate analysis of low birthweight deliveries (MTC-only cohort). Bivariate analysis of the entire cohort was replicated on the subset of mothers who did not receive any antenatal care outside of Mae Tao Clinic.

	Overall¹ <i>n</i> = 16,769	Normal Birthweight¹ <i>n</i> = 14,638	Low Birthweight¹ <i>n</i> = 2,131	p-value²	q-value³
Ethnicity				0.7	0.7
Burmese	10,839 (65%)	9,480 (65%)	1,359 (64%)		
Karen	2,425 (14%)	2,105 (14%)	320 (15%)		
Mon	233 (1.4%)	199 (1.4%)	34 (1.6%)		
Other	3,272 (20%)	2,854 (19%)	418 (20%)		
Age				<0.001	<0.001
< 20 years	1,416 (8.7%)	1,228 (8.4%)	233 (11%)		
20 – 35 years	13,059 (78%)	11,459 (78%)	1,600 (75%)		
> 35 years	2,249 (13%)	1,915 (13%)	298 (14%)		
Gravida					
Nulligravida	7182 (43%)	6,082 (42%)	1,100 (52%)		
1	4,125 (25%)	3,668 (25%)	457 (21%)		
2	2,403 (14%)	2,165 (15%)	238 (11%)		
3	1,366 (8.1%)	1,230 (8.4%)	136 (6.4%)		
4+	1693 (10%)	1,493 (10%)	200 (9.4%)		
Prior Miscarriage				0.015	0.024
No	13,741 (82%)	11,954 (82%)	1,787 (84%)		
Yes	3,028 (18%)	2,684 (18%)	344 (16%)		
Family Planning Visit				<0.001	<0.001
No	14,466 (86%)	12,568 (86%)	1,898 (89%)		
Yes	2,303 (14%)	2,070 (14%)	233 (11%)		
Number of 1st Trimester ANC Visits					
0	12,905 (77%)	11,216 (77%)	1,689 (79%)		
1	2,464 (15%)	2,171 (15%)	293 (14%)		
2	1,001 (6.0%)	891 (6.1%)	110 (5.2%)		
3+	399 (2.4%)	360 (2.5%)	39 (1.8%)		
Number of 2nd Trimester ANC Visits					
0	6,876 (41%)	5,846 (40%)	1,030 (48%)		
1	4,791 (29%)	4,240 (29%)	551 (26%)		
2	3,663 (22%)	3,257 (22%)	406 (19%)		
3+	1,439 (8.6%)	1,295 (8.8%)	144 (6.8%)		
Number of 3rd Trimester ANC Visits					
0	3,244 (19%)	2,860 (20%)	384 (18%)		
1	6,181 (37%)	5,368 (37%)	813 (38%)		
2	4,698 (28%)	4,077 (28%)	621 (29%)		
3+	2,646 (16%)	2,333 (16%)	313 (15%)		

¹ Statistics presented: n (%), mean (standard deviation)² Statistical tests performed: chi-square test of independence³ False discovery rate correction for multiple testing

Table S3. Logistical regression modeling low birthweight deliveries (MTC-only cohort). Regression analysis of the entire cohort was replicated on the subset of mothers who did not receive any antenatal care outside of Mae Tao Clinic. Notably, the impact of family planning service utilization lost significance in the final model in this cohort of mothers. However, the impact of third trimester ANC visits gained statistical significance.

	Odds Ratio	95% Confidence Interval	p-value
Ethnicity			0.50
Other	-	-	
Burmese	0.93	[0.83, 1.05]	
Karen	0.98	[0.84, 1.15]	
Mon	1.11	[0.75, 1.60]	
Age			<0.001
20 – 35 years	-	-	
< 20 years	1.19	[1.02, 1.39]	
> 35 years	1.15	[1.22, 1.65]	
Gravida	0.88	[0.84, 0.91]	<0.001
Prior Miscarriage			0.25
No	-	-	
Yes	1.09	[0.94, 1.25]	
Family Planning Visit			0.10
No	-	-	
Yes	0.88	[0.76, 1.02]	
Number of 1st Trimester ANC Visits	0.89	[0.83, 0.95]	<0.001
Number of 2nd Trimester ANC Visits	0.84	[0.80, 0.88]	<0.001
Number of 3rd Trimester ANC Visits	0.95	[0.91, 0.99]	0.03