



BMJ Open Access to community-based reproductive health services and incidence of low birthweight delivery among refugee and displaced mothers: a retrospective study in the Thailand-Myanmar border region

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ABSTRACT

Objectives Over 2.4 million people have been displaced within the Thailand-Myanmar border region since 1988. The efficacy of community-driven health models within displaced populations is largely unstudied. Here, we examined the relationship between maternal healthcare access and delivery outcomes to evaluate the impact of community-provided health services for marginalised populations.

Setting Study setting was the Thailand-Myanmar border region's single largest provider of reproductive health services to displaced mothers.

Participants All women who had a delivery (n=34 240) between 2008 and 2019 at the study clinic were included in the performed retrospective analyses.

Primary and secondary outcome measures Low birth weight was measured as the study outcome to understand the relationship between antenatal care access, family planning service utilisation, demographics and healthy deliveries.

Results First trimester (OR=0.86; 95% CI=0.81 to 0.91) and second trimester (OR=0.86; 95% CI=0.83 to 0.90) antenatal care visits emerged as independent protective factors against low birthweight delivery, as did prior utilisation of family planning services (OR=0.82; 95% CI=0.73 to 0.92). Additionally, advanced maternal age (OR=1.36; 95% CI=1.21 to 1.52) and teenage pregnancy (OR=1.27, 95% CI=1.13 to 1.42) were notable risk factors, while maternal gravidity (OR=0.914; 95% CI=0.89 to 0.94) displayed a protective effect against low birth weight.

Conclusion Access to community-delivered maternal health services is strongly associated with positive delivery outcomes among displaced mothers. This study calls for further inquiry into how to best engage migrant and refugee populations in their own reproductive healthcare, in order to develop resilient models of care for a growing displaced population globally.

INTRODUCTION

Refugee and displaced mothers experiencing pregnancy are among the world's

Strengths and limitations of this study

- The impact of community-delivered reproductive health services on maternal health outcomes is largely unstudied in populations impacted by civil unrest, such as the 2.4 million people who have been displaced within the Thailand-Myanmar border region since 1988.
- This is the first study to directly examine the impact of community-based reproductive health services on delivery outcomes within a displaced and refugee population, demonstrating a clear relationship between community-based care and healthy deliveries.
- These results corroborate the clear association between antenatal care access, family planning services access and infant and maternal health outcomes established by population modelling studies globally.
- This study invites further exploration of how to best engage displaced and refugee populations in their own reproductive healthcare, which has the potential to improve care quality and access for those unsupported by formal healthcare systems globally.
- Limitations of this study include the inability to quantify the impact of geography on maternal health outcomes in this highly mobile population, and ongoing lack of consensus on the value of birth weight as a prognostic indicator of health and point of intervention.

most vulnerable populations. Inadequate shelter, increased prevalence of gender-based violence and limited access to education and employment are among the challenges faced by displaced mothers during critical childbearing months, putting them distinctly at risk compared with refugee men and the



non-displaced at large.^{1,2} The issue of refugee maternal health is underscored by the rising population of displaced persons worldwide. The United Nations High Commissioner for Refugees (UNHCR) estimates that over 80 million people globally were forcibly displaced as of 2020, up from <20 million in 2010.³ Among them is a growing population of women of reproductive age, whose experiences of pregnancy will have implications for their own health and the health of future generations numbering in the millions.⁴

The pressing need for reproductive healthcare among displaced populations is clearly established^{5,6}; however, challenges to implementing effective systems of care delivery persist.^{7,8} There is an emerging consensus on the value of community-delivered maternal healthcare in low-resource healthcare settings.^{9–12} The role of midwifery has also seen renewed interest, with a number of studies establishing the potential impact to improving access and quality of maternal healthcare.¹³ However, few examples support the feasibility of such community-centred care models within displaced populations,¹⁴ and none to our knowledge directly evaluate the impact on maternal health outcomes.

Directly studying maternal healthcare delivery within actively displaced populations is challenging. The transient and mobile nature of migrant groups fundamentally limits opportunities for investigation to rare cases of sizeable and persistently displaced populations. One such setting is the Thailand-Myanmar border region, home to one of the longest-standing refugee and migrant populations globally. Over 2 million people have lived displaced between eastern Myanmar and northwestern Thailand for the last 30 years. A network of community-based ethnic health organisations serves the large population with significant barriers to accessing health services through formal healthcare systems.¹⁵ This ethnic health system presents the opportunity to examine the efficacy of a community-established system of reproductive healthcare

that has continuously served its displaced population through ongoing political unrest for nearly a generation.

There are many obstacles to providing effective care to refugee populations. Programmatic challenges to designing effective systems of care delivery in displaced populations are widely documented,^{7,8} and range from limitations of international funding to operationalisation concerns. Non-governmental and community-based organisations, especially those disconnected from formal healthcare systems, must often rely on external grants and inconsistent funding streams to accomplish critical humanitarian work. Even with adequate resources available, displaced and refugee mothers face numerous barriers to accessing their care, ranging from volatile security situations and statelessness to cultural obstacles and transportation issues (table 1).

This study adds to other published studies in suggesting that direct support of community-coordinated reproductive health programmes represent a potential avenue for addressing these concerns. As the international community makes efforts to support those threatened by reinvigorated political instability in the region, the evidence presented here suggests that community-based organisations will be critical for sustaining essential reproductive health services to those already marginalised by government-based systems.

In this study, we examined 12 years of delivery outcomes and reproductive healthcare service utilisation among a cohort of refugee and internally displaced mothers who delivered at the Mae Tao Clinic (MTC). MTC is a community-established clinic in Mae Sot, Thailand that serves as the region's single largest provider of maternal health services for the displaced. This study focused on the outcome of low birth weight, a critical prognostic indicator of infant health,¹⁶ to better understanding the relationship between antenatal care access, family planning service utilisation, demographics and healthy deliveries among this underserved population. Through assessing

Table 1 Barriers to accessing reproductive health services in the Thailand-Myanmar border region

Category	Barriers to care
Political	<ul style="list-style-type: none"> ▶ <i>Statelessness and political identity</i>: many migrants and refugees have neither Thai nor Myanmar citizenship, making governmental public healthcare inaccessible or prohibitively expensive. ▶ <i>Volatile security situation</i>: ongoing armed conflict in Myanmar's Karen State displaces mothers across the border to Tak Province in Thailand, where they must re-establish care in a foreign country.
Logistical	<ul style="list-style-type: none"> ▶ <i>Lack of health system access in rural areas</i>: health systems, both governmental and those established by Ethnic Health Organizations, have difficulty providing access in the region's most remote localities. ▶ <i>Transportation limitation</i>: public transportation is limited across the clinic's geographically wide catchment area. Many mothers must use informal and unreliable shared transportation options to present for care.
Cultural	<ul style="list-style-type: none"> ▶ <i>Language barriers</i>: members of the region's Karen population may not speak Burmese or Thai, limiting conversation with providers at government-established hospitals and clinics. ▶ <i>Discrimination at the point of care</i>: perceptions of migrant and refugee identity, including ethnic minority status and legal status within Thailand, are often cited as unavoidable barriers to accessing quality care within formally established health systems.

A simplified framework for understanding the broad categories of barriers faced by migrant and refugee mothers living within Mae Tao Clinic's catchment area.

trends in birth weight outcomes in this context, we sought to understand the impact of community-delivered care in this marginalised population of mothers in the Thailand-Myanmar border region.

METHODS

Study setting

MTC is located in Mae Sot, a city in Thailand's north-western Tak Province that shares its western border with Karen State, Myanmar. The border region has been the site of conflict between the Myanmar military and ethnic minority groups since 1988.^{17 18} Ongoing violence in eastern Myanmar has displaced 2.4 million migrants into Thailand during that time, with reasons for migration ranging from violence and persecution to economic motivations.^{19 20} Approximately 110 000 reside as officially registered refugees in camps along the Thailand-Myanmar border.²¹ The remaining majority are categorised as 'irregular migrants', lacking official political status in Thailand.²¹ Although Myanmar's 2015 democratic elections suggested a transition towards peace in the region, the 1 February 2021 military coup d'état was a reminder of the ongoing instability in the region.

Since 1989, a system of Ethnic Health Organizations (EHOs) has developed to provide care to the largely unserved group of migrants, refugees and displaced persons in the region. MTC has played a central role in coordinating the health system development, while simultaneously providing free health services across an estimated catchment area of over 1 million (figure 1). Founded by Dr Cynthia Maung, a refugee herself, the clinic is rooted entirely in the migrant community, operating independently from government health systems. MTC's health and administrative teams are staffed by local community health workers (CHWs) and managers, and supported largely by international grants (including United States Agency for International Development (US AID), United Kingdom Aid (UK AID) and the International Rescue Committee). Having provided over 135 000 antenatal care consultations, over 75 000 family planning consultations and supported over 34 000 deliveries since 2007, MTC is the region's single largest provider of reproductive health services for migrants, refugees and the displaced in the region.

The overall landscape of healthcare options for the region's displaced population is diverse. Health centres exist within the border region's numerous refugee camps and are supported by international organisation such as UNHCR. Independent institutionally affiliated organisations, such as Shoklo Malaria Research Unit, also provide maternal healthcare services alongside a variety of missionary and religious groups in the region. Finally, numerous other ethnic health organisations, such as The Karen Department of Health and Welfare, Backpack Health Workers and The Burma Medical Association, work closely with MTC to support the needs of the region's most underserved. In light of this complex

system, care access patterns are difficult to characterise. While mothers with risk factors or complicated antenatal courses may be more likely to present to MTC for health services, these motivations are difficult to untangle from cultural, political and financial reasons for using the clinic over alternative sources of care.

Prior research within the region's EHO network have helped to characterise the successes and ongoing challenges of task-shifting maternal health services for displaced mothers to a community-based approach.¹⁵ In 2008, Mullaney *et al* completed a comprehensive survey of maternal health access in the border region, highlighting the significant impact that the overarching political, developmental and human rights context has had on reproductive and maternal health among displaced populations.^{22 23} More recent works have used focus group interviews with migrant mothers and lay maternal CHWs to illuminate ongoing barriers to care, and understand local perceptions of reproductive health.^{24–27} To date, there has been no investigation of the relationship between access to community-delivered health services and individual delivery outcomes among the mothers in the region, leaving the direct impact of these community care models on obstetric outcomes largely unquantified at the population level.

Despite growing consensus around the value of task-shifting to improve maternal health in low-income and middle-income country,^{28 29} little work has demonstrated the feasibility and impact of community care models within refugee and migrant populations, usually among the most vulnerable and underserved in any low-resource setting. In addition to establishing the impact of community-based reproductive healthcare, the results of this study call for further exploration of the ongoing barriers to care facing displaced mothers in the region. Notably, 33% of mothers in the cohort met the current WHO recommendation of four antenatal care (ANC) visits during pregnancy. This figure lags behind national averages for Myanmar (59%) and Thailand (91%),³⁰ underscoring the underserved nature of this population. Since March 2020, periodic closures of the Thailand-Myanmar border, due to the COVID-19 pandemic, have presented yet another barrier to care. The critical need to improve reproductive care access among the region's displaced population is further heightened by the Myanmar military's seizure of government power on 1 February 2021. Although the ramifications of this political development are still unfolding, it has already shown signs of exacerbating the issues of statelessness, political autonomy and discrimination that reinforce inequalities in care access and health outcomes in the region.

Data extraction

This study was a retrospective review of all deliveries that occurred at MTC between June 2007 and December 2019 (n=34 240). Data were extracted from MTC's Health Information System (HIS; details given in online supplemental material) located in Mae Sot, Thailand. Data aggregation

conception. Two demographic variables were included as covariates: (1) ethnicity and (2) maternal age. Ethnicity was aggregated into the three predominant ethnicities among MTC's patient population (Burmese, Karen and Mon) and one additional category to encompass the remaining heterogeneous mix of other ethnic identities. Maternal age was stratified into three groups to capture high-risk cohorts defined by teenage pregnancy and advanced maternal age: (1) <20 years old; (2) 20–35 years old and (3) >35 years old. Two variables related to pregnancy history were included as potential maternal health risk factors: (1) maternal gravidity and (2) any history of prior miscarriage. Cases for which any variable was missing were excluded, leaving a total of 30 209 deliveries for final analysis. Validation was performed to confirm that the excluded mothers were similar to the final study cohort in terms of outcomes, demographics, care utilisation and risk factors.

Bivariate analyses and logistic regression

Deliveries were segregated based on birthweight outcome (ie, low birth weight or normal birth weight) and bivariate analysis was performed across all variables. The χ^2 calculations were conducted for categorical variables (ethnicity, age, history of miscarriage and family planning utilisation). Following bivariate analysis, a multiple logistic regression was performed to assess for independent predictors of low birth weight across all independent variables. An alpha of 0.05 was set for determination of statistical significance in all analyses.

Geographic analyses

Information on geographic district of origin was available for all mothers included in the final study cohort, providing the opportunity to observe trends in risk factors, care utilisation and outcomes across MTC's geographically wide catchment area. ArcGIS was used to produce a cartographic representation of low birthweight deliveries based on mothers' district of origin (figure 2). Study variables were then aggregated by district, and z-scores for each district-variable pair were computed. These z-scores, which reflect geographic variation within the dataset, were then visualised in a heatmap to assess for trends in care utilisation, demographics, risk factors and birthweight outcomes (figure 3).

Temporal analyses

Temporal analysis was also performed to assess for changes in demographics, risk factors and outcomes in the cohort during the study period. In particular, political developments in 2012 loosened restrictions on cross-border travel and improved access to care in eastern Myanmar. Disparities between the pre-2012 and post-2012 periods lend insight into the health impacts of regional politics, and allow us to evaluate trends in outcomes that co-occurred with community-led efforts to strengthen the region's ethnic health system. All independent variables, as well as prevalence of low birthweight delivery, were aggregated

by year to assess for any overarching temporal trends. The Mann-Kendall 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 the political developments that year which expanded cross-border health service access for migrants. A bivariate analysis of all variables pre-2012 and post-2012 was conducted, following the same methodology noted above.

RESULTS

Yearly low birthweight prevalence displayed a 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 analysis confirmed this trend in low birthweight delivery ($\tau=-0.727$, $\alpha=0.001$), and also revealed trends towards increased utilisation of first trimester ANC visits ($\tau=0.795$, $p<0.001$), second trimester ANC 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-2012 and post-2012 corroborated these trends, revealing numerous significant results across our independent variables (online supplemental table S1). Notably, the average number of first trimester ANC visits 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%). Further discussion and context around temporal trends in demographics, care utilisation and outcomes can be found in the online supplemental material.

Bivariate analysis of deliveries segregated by birthweight outcome revealed numerous statistically significant differences between the two cohorts (table 2). Considering reproductive healthcare utilisation, low birthweight deliveries were associated with fewer first trimester ANC visits and second trimester ANC visits compared with normal birthweight deliveries. Mothers who delivered low birthweight infants also used family planning services at a lower rate (11% vs 14%, $p<0.001$). From the demographic variables, maternal age category was significantly associated with birthweight outcome ($p<0.001$), with mothers who delivered low birthweight infants more likely to be under the age of 20 (11% vs 8.1%) or over the age of 35 (15% vs 14%) years. Considering pregnancy history, low birthweight deliveries were associated with mothers with lower gravidity, and also concomitant with a lower incidence of prior miscarriage (16% vs 18%, $p=0.003$). Ethnicity showed no significant correlation with delivery

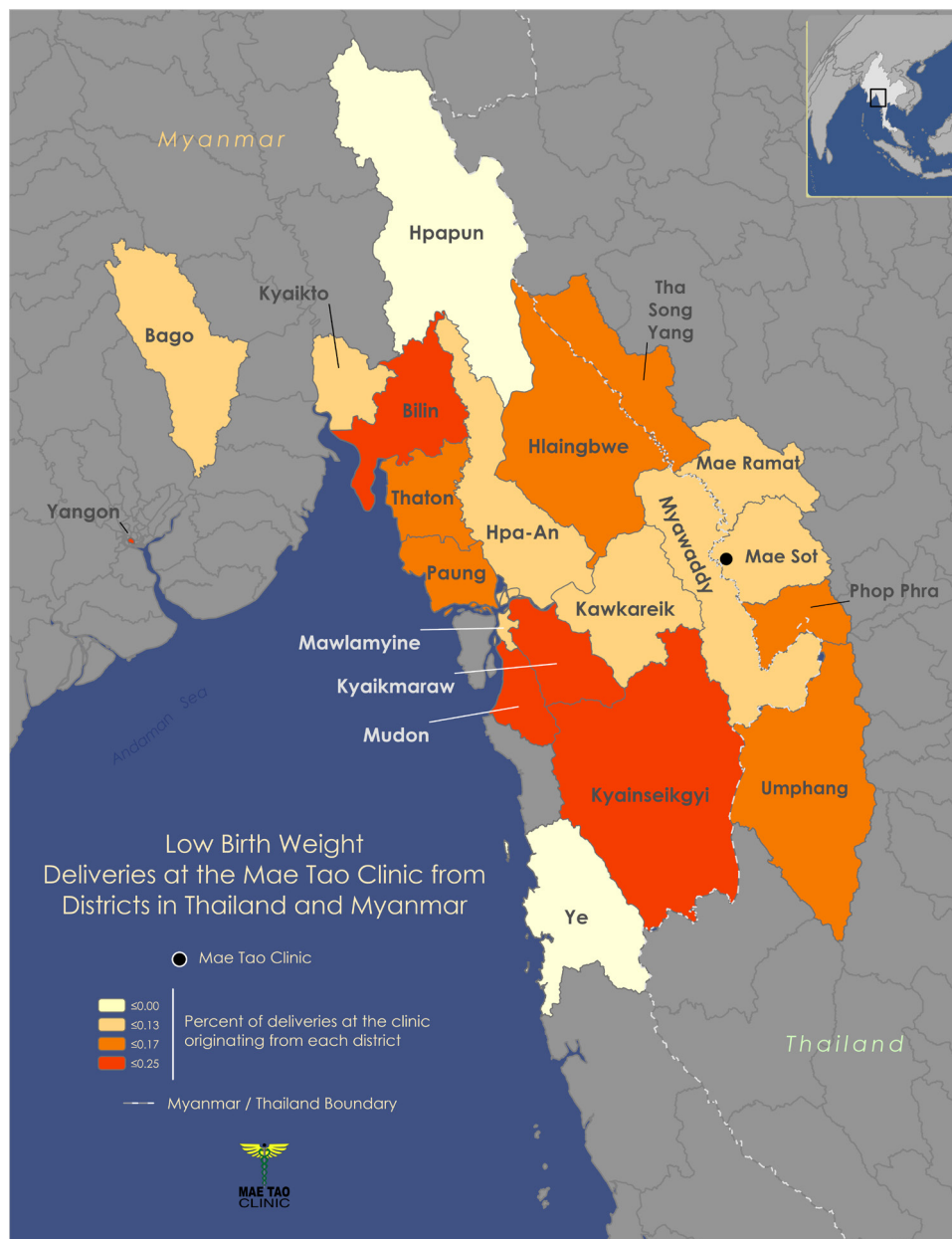


Figure 2 Low birthweight deliveries at Mae Tao Clinic (MTC) by patient district of origin. The proportion of mothers from each district who experienced low birthweight deliveries was calculated and used to colour this map. As in figure 1, the migrant nature of MTC's patient population limits any strong conclusions regarding individual districts included here. The map instead provides a look into the diversity of outcomes across MTC's expansive catchment area. Mae Sot and the neighbouring districts of Myawaddy and Mae Ramat displayed the lowest incidences of low birthweight deliveries (<math>< 13\%</math>). Mothers from more distant districts such as Hpa-An and Bago ultimately displayed similar outcomes. Nation of origin also offered no clear distinction in birthweight outcomes. Mothers travelling from the Myanmar districts of Hpapun and Ye, nearly an entire day's journey from MTC, displayed some of the best outcomes, while mothers arriving from the nearby Thai district of Phop Phra displayed higher rates of low birthweight deliveries.

outcome. In separate bivariate analysis assessing for satisfaction of WHO ANC guidelines, mothers who delivered low birthweight infants were less likely to have met the prior recommendation of four total ANC visits during pregnancy (26% vs 34%, $p < 0.001$) than those who were able to meet the guideline.

Logistical regression confirmed the relationships established by bivariate analysis (table 3). The number of first trimester ANC visits (OR=0.86; 95% CI=0.81 to 0.91)

and number of second trimester ANC visits (OR=0.86; 95% CI=0.83 to 0.90) emerged as independent protective factors against low birthweight delivery across the cohort, as was prior utilisation of family planning services (OR=0.82; 95% CI=0.73 to 0.92). The number of third trimester ANC visits did not show a significant correlation with outcomes. From among demographic factors, maternal age also showed a statistically significant correlation with birthweight outcome, with mothers under the

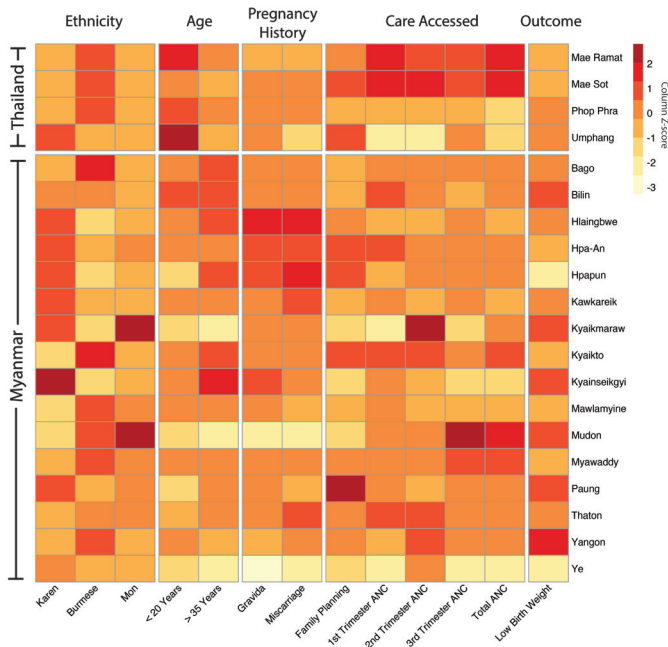


Figure 3 Dataset variation by mothers' district of origin. This heatmap visualises variation in demographics, access to services at Mae Tao Clinic and delivery outcomes (x-axis labels) based on mothers' most recent district of origin prior to delivery (y-axis labels). This geographic variation may be used for future hypothesis generation, and provide a tractable starting point for exploring how patients from these districts differentiate themselves among the overall population risk factors. When considered alongside the results of the regression analysis, the heatmap provides an intuitive means for understanding which patient subpopulations might be contributing most significantly to broader trends, and therefore be disproportionately at risk for adverse outcomes.



Figure 4 Trend in low birthweight delivery. The chart displays a general downward trend over the course of the study period, which is confirmed by the results of the Mann-Kendall test ($\tau = -0.727$, $p = 0.001$). Changes in outcomes over time might reflect a confluence of factors influencing access to care in the region's displaced population, most importantly ongoing health systems strengthening efforts in eastern Myanmar.

age of 20 years (OR=1.27, 95% CI=1.13 to 1.42) and those over the age of 35 years (OR=1.36; 95% CI=1.21 to 1.52) emerging as independent risk factors. In terms of pregnancy history, maternal gravidity displayed a protective effect against low birthweight delivery (OR=0.92; 95% CI=0.89 to 0.94).

Our cartographic representation of low birthweight deliveries by mothers' district of origin yielded no obvious trend in outcomes based on geographic distance from MTC (figure 2). However, heatmap visualisation revealed significant variation in the cohort based on district of origin (figure 3). Mothers who self-reported Mae Sot as their district of origin displayed the highest utilisation of MTC's reproductive health services, while remote districts such as Kyainseikgyi displayed some of the lowest utilisation figures. Among variables tracking demographics and pregnancy history, a number of districts stood out as outliers. For example, mothers from Hlaingbwe displayed meaningfully higher maternal gravidity and history of prior miscarriage compared with those from other districts. Examining age, Mae Sot's nearby Thai district of Mae Ramat produced the highest proportion of teenage mothers, exceeded only by Umphang. The proportion of mothers over the age of 35 years was far more evenly distributed across all districts.

DISCUSSION

To our knowledge, this is the first study to directly examine the impact of community-based reproductive health services on delivery outcomes within a displaced and refugee population, demonstrating a clear relationship between community-based care and healthy birthweight delivery. Our results indicate that access to CHW-delivered antenatal care services at MTC during the first two trimesters of pregnancy is independently correlated with healthy birthweight delivery across the cohort. Utilisation of family planning services prior to conception was also found to be independently associated with positive outcomes, with both associations remaining significant even when adjusted for ethnicity, age, gravidity and history of prior miscarriage. Encompassing over 30 000 deliveries spanning 12 years of care, these results represent strong evidence in support of the positive impact of community-based reproductive healthcare on maternal health outcomes in this underserved cohort of mothers.

Our findings corroborate existing consensus in the maternal health literature. Associations between ANC service utilisation and improved infant and maternal health outcomes have been extensively validated globally.³¹ Population modelling studies assessing the impact of family planning services have also consistently revealed an association between such reproductive services and positive maternal health outcomes.³² Although questions of standardisation of healthcare services across disparate settings remain an issue, MTC's care protocols follow widely accepted guidelines for ANC services and family planning recommendations established by WHO.³³ More

**Table 2** Bivariate analysis of deliveries by birthweight outcome

	Overall* n=30 209	Normal birth weight* n=26 415	Low birth weight* n=3794	P value†	Q value‡
Ethnicity				0.2	0.2
Burmese	19 278 (64%)	16 918 (64%)	2360 (62%)		
Karen	4566 (15%)	3963 (15%)	603 (16%)		
Mon	436 (1.4%)	380 (15%)	56 (1.5%)		
Other	5929 (20%)	5154 (20%)	775 (20%)		
Age (years)				<0.001	<0.001
<20	2552 (8.4%)	2142 (8.1%)	410 (11%)		
20–35	23 387 (77%)	20 579 (78%)	2808 (74%)		
>35 years	4270 (14%)	3694 (14%)	576 (15%)		
Gravida					
Nullgravida	12 702 (42%)	10 806 (41%)	1896 (50%)		
1	7477 (25%)	6674 (25%)	803 (21%)		
2	4389 (15%)	3959 (15%)	430 (11%)		
3	2529 (8.4%)	2246 (8.5%)	283 (7.5%)		
4+	3112 (10%)	2730 (10%)	382 (10%)		
Prior miscarriage				0.003	0.004
No	24 798 (82%)	21 617 (82%)	3181 (84%)		
Yes	5411 (18%)	4798 (18%)	613 (16%)		
Family planning visit				<0.001	<0.001
No	26 022 (86%)	22 634 (86%)	3388 (89%)		
Yes	4187 (14%)	3781 (14%)	406 (11%)		
Number of first trimester ANC visits					
0	24 044 (80%)	20 893 (79%)	3151 (83%)		
1	3985 (13%)	3550 (13%)	435 (11%)		
2	1594 (5.3%)	1435 (5.4%)	159 (4.2%)		
3+	586 (2.0%)	537 (2.0%)	49 (1.3%)		
Number of second Trimester ANC visits					
0	15 918 (53%)	13 679 (52%)	2239 (59%)		
1	7283 (24%)	6442 (24%)	841 (22%)		
2	5085 (17%)	4552 (17%)	533 (14%)		
3+	1923 (6.4%)	1742 (6.6%)	181 (4.8%)		
Number of third trimester ANC visits					
0	10 586 (35%)	9218 (35%)	1368 (36%)		
1	9691 (32%)	8487 (32%)	1204 (32%)		
2	6468 (21%)	5653 (21%)	815 (21%)		
3+	3464 (11%)	3057 (12%)	407 (11%)		

The final cohort for analysis included 30 209 deliveries, 3794 of which were designated as low birth weight per the standard cut-off of 2.5 kg. Age, prior miscarriage and prior family planning service utilisation all displayed statistically significant differences between the two groups based on χ^2 analysis.

*Statistics presented: n (%), mean (SD).

†Statistical tests performed: χ^2 test of independence.

‡False discovery rate correction for multiple testing.

ANC, antenatal care.

Table 3 Logistical regression modelling low birthweight outcomes

	OR	95% CI	P value
Ethnicity			0.069
Other	–	–	
Burmese	0.89	0.82 to 0.98	
Karen	0.96	0.86 to 1.08	
Mon	0.93	0.69 to 1.23	
Age (years)			<0.001
20–35	–	–	
<20	1.27	1.13 to 1.42	
>35	1.36	1.22 to 1.52	
Gravida	0.92	0.89 to 0.94	<0.001
Prior miscarriage			0.55
No	–	–	
Yes	1.03	0.93 to 1.15	
Family planning visit			<0.001
No	–	–	
Yes	0.82	0.73 to 0.92	
Number of first trimester ANC visits	0.86	0.81 to 0.91	<0.001
Number of second trimester ANC visits	0.86	0.83 to 0.90	<0.001
Number of third trimester ANC visits	0.97	0.94 to 1.00	0.087

Antenatal care access during the first trimester and second trimester emerged as independent protective factors against low birthweight delivery in the final model. Prior utilisation of family planning services was also correlated with lower odds of low birthweight delivery when adjusted for all other covariates. Pregnancy history as measured by maternal gravida displayed a protective effect against low birthweight delivery, while teenage pregnancy and advanced maternal age emerged as independent risk factors. ANC, antenatal care.

information on MTC's services can be found in the online supplemental material.

Our study also quantifies the significant diversity in outcomes, care utilisation, demographics and pregnancy history based on mothers' district of origin. Geography is critical for contextualising the complexities of care delivery in this widely dispersed cohort. A patient's proximity to care, as well as relative mobility and permanence of residence, is an unavoidable confounding factor when examining trends among any mobile population. Beyond contextualising the dataset used in this study, the geographic diversity also represents a tractable starting point for exploring interventions to address disproportionate pregnancy risk faced by certain subcohorts. For example, the heatmap (figure 4) revealed that mothers arriving from the Thai district of Umphang accounted for a disproportionate number of teenage pregnancies during the study period. Teenage pregnancy is independently

associated with greater risk of low birthweight delivery in our final model (table 3), and furthermore mothers from Umphang also displayed lower utilisation of first and second trimester visits, both indicated to be protective factors across the population. Umphang mothers did, however, access family planning resources prior to conception more often than their peers. These findings suggest the possibility of providing targeted counselling around pregnancy risk factors during family planning visits, and calls for further investigation into the barriers to seeking care earlier in pregnancy among mothers from this district.

This study has several limitations. First, the reproductive care utilisation data presented here only reflects care provided by MTC, and as such does not reflect ANC, family planning services and other forms of reproductive care accessed outside of the clinic. To account for this, bivariate analysis and logistical regression modelling were repeated on the subset of mothers reporting no external visits (n=16 769, approximately 56% of the total cohort) and results were highly comparable within this subgroup (online supplemental table S2 and S3). The geographic analysis presented here also comes with a caveat. Given the highly mobile nature of MTC's patient population, a mother's self-reported district of origin at the time of delivery may not necessarily reflect her place of residence throughout a pregnancy. It is also common for mothers travelling from afar to temporarily reside close to MTC to ensure access to care. Such tendencies make it difficult to assess the true value of patient-reported geographic information, and more broadly highlight the complexities in understanding how changes in location, access to transportation and presence of local social supports confound trends in outcomes within migrant populations. Finally, the use of birth weight as a prognostic indicator of health and point of intervention is still actively debated, with recent meta-analyses suggesting that the applications of birth weight alone may be more limited than previously thought.³⁴ However, in settings of episodic care such as this, more actionable indicators such as prematurity are sometimes difficult to assess. Birth weight thus remains a reliably measured and widely studied outcome to compare marginalised populations with those globally.³⁵

External factors not accounted for in analysis may also act as confounders in the relationship between healthcare provision and positive delivery outcomes in this setting. For example, increased access to contraceptives in the region has led to fewer unintended pregnancies over time. Alongside decreases in miscarriages and abortions, this is thought to be the single largest factor behind improving maternal outcomes in the region. Mothers who receive care at MTC may well represent a self-selected cohort of those more willing to engage with maternal healthcare and therefore less likely to suffer the consequent risks associated with unintended pregnancy. Furthermore, malaria eradication efforts have reduced infection rates among pregnant migrants, alongside improvements in access to nutrition supplementation including iodine, folate

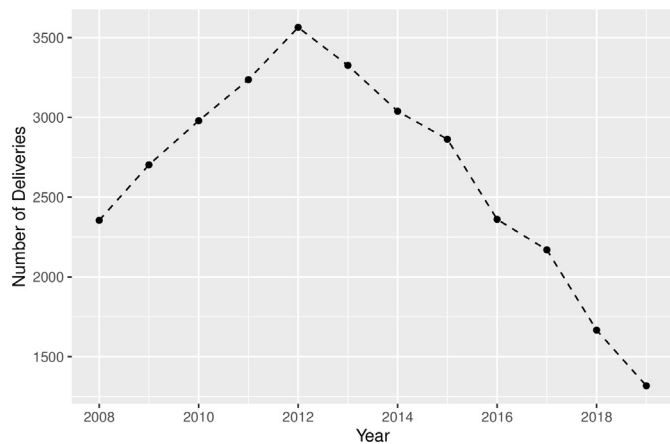


Figure 5 Trend in number of deliveries at Mae Tao Clinic. The number of deliveries peaked in 2012 with 3564 deliveries, and has steadily declined since then (down to 1318 deliveries in 2019). The reason for this trend is difficult to determine with certainty, however increased access to alternative sources of care on the Myanmar side of the border following political developments in 2012 is likely a key factor at play.

and iron. Both represent other potential confounders of trends in maternal care outcomes in the region over the 12-year study period.

Based on our findings, we propose further study in the Thailand-Myanmar border region to address critical gaps in knowledge regarding the access and utilisation of maternal healthcare. As COVID-19 establishes itself as an ongoing public health concern in the border region, more work must be done to understand the impact of epidemics on vulnerable populations. Emerging evidence from MTC's HIS points to large declines in migrant patient volumes due to recent cross-border quarantine mandates (figure 5), as well as concomitant staff shortages as community-based groups were forced to dismiss workers to avoid outbreaks. Unfortunately, insufficient data exist to date to properly analyse prepandemic and intrapandemic trends, as the region continues to be greatly affected. However, prior work in other resource-limited regions provide a template for further investigation. For example, observational studies in Sierra Leone have elucidated the impact of the Ebola outbreak on rural reproductive health services.³⁶ Other studies have examined issues of infection after delivery and availability of HIV services in the context of pregnancy, two other pivotal areas for future exploration in the Thailand-Myanmar border region.^{37 38}

CONCLUSION

Based on these findings we propose that, as international aid enters to region in the wake of increasing political unrest and ongoing COVID-19 concerns, resources be targeted towards ethnic health organisations and community-based groups who provide essential services to displaced individuals unsupported by government health systems. More generally, our findings suggest that

community-based reproductive health systems may function as effective care delivery models in long-standing refugee and migrant populations. Furthermore, specific attention must be given to developing effective health information systems in low-resource settings, which are essential to supporting future population health investigation like this study. Such health data systems will be essential as we seek to understand and address the needs of growing displaced populations worldwide.

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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.

	Overall¹ <i>n</i> = 30,209	Before 2012¹ <i>n</i> = 14,071	After 2012¹ <i>n</i> = 16,138	p-value²	q-value³
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