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Improving monitoring of engagement in HIV care for women in Option B+: a pilot test of biometric fingerprint scanning in Lilongwe, Malawi

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Abstract

Background—Sustained engagement in HIV care is critical to the success of Option B+ for HIV-infected pregnant women. However, monitoring women's engagement in care across clinics and over time is challenging due to migration and clinic transfers. Improved strategies to identify and monitor women's engagement in HIV care across a network of clinics are needed, but have not been pilot tested. We evaluated the feasibility and acceptability of biometric fingerprint scanning to identify women and monitor HIV visit attendance among women in Option B+.

Methods—Over a three-month period, we enrolled HIV-infected pregnant women receiving care at two antenatal clinics in Lilongwe, Malawi and monitored their engagement in care using biometric fingerprint scanning and the standard-of-care electronic medical record (EMR) monitoring system. Biometric data was collected by trained research assistants, who uploaded and synced data across study sites daily using wireless internet. We collected data weekly on the biometric scanner performance, reliability, and usability. We assessed the feasibility and

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acceptability of using biometric fingerprint scanning to record HIV visits during exit interviews with a sample of participants and healthcare workers and by comparing visit concordance between the biometric fingerprint scanning and EMR systems.

Results—We enrolled 314 HIV-infected pregnant women and 51 HCWs (n=365 total participants). The majority of participants felt the biometric fingerprint scanning system was easy to use (64%), required no additional assistance (69%) and met their expectations (76%). No major issues with data security, privacy, or scanner functionality were reported by HIV-infected women or healthcare workers. Of the 542 HIV visits captured during the study period among women in Option B+, 80% were recorded in the biometric fingerprint system versus 51% in the EMR system (PR 1.57, 95% CI 1.43, 1.72, p-value <0.05).

Conclusions—Among HIV-infected pregnant women engaged in HIV care, biometric fingerprint scanning is a feasible and acceptable way to monitor HIV visits and may improve the ability to monitor women's engagement in HIV care over time and across clinics. Biometric fingerprint scanning should be scaled-up and evaluated as an implementation strategy to support sustained engagement in HIV care for women during the perinatal period.

Keywords

biometrics; biometric fingerprint scanning; engagement in HIV care; monitoring; HIV; feasibility and acceptability

Introduction

In 2013, Malawi became the first country to implement universal lifelong antiretroviral (ART) initiation for all pregnant and breastfeeding women under the Option B+ program(1, 2). A wealth of evidence supports the potential for Option B+ to significantly reduce mother-to-child and sexual HIV transmission, improve maternal health, and contribute to achieving UNAIDS' goal of 90% of HIV-infected adults on ART(1, 3–6). However, disengagement from HIV care may limit the effectiveness of Option B+ to improve HIV outcomes. Nearly 25% of women in Option B+ are lost to follow-up (LTFU) within 12 months of initiating ART, making long-term engagement in HIV care a barrier to the successful implementation of Option B+(7, 8).

Monitoring and supporting women's engagement in HIV during the perinatal period is critical to achieving improved HIV outcomes, but in practice is difficult. Pregnant women are five times as likely to not return to HIV care, compared to non-pregnant women initiating ART, and disengagement from HIV care is highest among pregnant women in the first year on ART(8, 9). Current monitoring systems typically require that women register for and receive HIV care at a particular clinic. Clinics monitor engagement in HIV care using either electronic medical records or paper-based systems, which are often not linked across clinics, making it challenging to monitor when women move from one clinic to another(10). Stigma, migration, and fears of inadvertently disclosing one's HIV status can lead women to move or "self-transfer" between HIV clinics, without first alerting their original clinic(11). In Malawi, an estimated 30% of women identified as LTFU from HIV treatment programs have self-transferred to a new HIV clinic(12). High rates of LTFU and

frequent self-transfers not only leads to underestimates of retention in care(13, 14), but hampers efforts to keep women on ART and virally suppressed(11). To address this challenge, the World Health Organization (WHO) recently endorsed a person-centered approach to monitoring engagement in HIV care, which emphasize the importance of identifying patients transferring clinics and linking patient data across healthcare facilities in order to support continuous engagement in HIV care(15). Despite the importance of sustained engagement in HIV care to the success of Option B+, few strategies to improve the ability to monitor engagement in HIV care have been evaluated.

In many resource-limited settings monitoring engagement in care over time and among patients who transfer between health facilities is challenging. Patients may present without their medical record information or provide different demographic information, making it difficult to identify them in existing records(11). Biometric fingerprint scanning may hold promise as a way to quickly and consistently identify patients when they transfer clinics, thereby supporting their sustained engagement in HIV care. In resource-limited settings biometric fingerprint scanning has been identified as feasible and acceptable strategy to identify patients, monitor healthcare visits, and link health records across multiple sources or locations(16–19). But the feasibility and acceptability of using biometric fingerprint scanning to monitor and support engagement in HIV care for HIV-infected women during the perinatal period is unknown. To address this gap, we assessed the feasibility and acceptability of biometric fingerprint scanning to identify women and monitor HIV visits in a pilot study in two large antenatal clinics in Lilongwe, Malawi.

Methods

Study setting

In Malawi, HIV testing during pregnancy is universal and women diagnosed with HIV-infection are initiated on ART on the same day. HIV and ART services are integrated into routine antenatal care (ANC) and are free of charge at government clinics(20). Increasingly, HIV-infected women in Malawi are entering ANC already taking ART(21). HIV-infected women are typically asked to present for care every 30–90 days during pregnancy, depending on if they are newly initiating or continuing ART. In Malawi, there is no recommended model of care for delivering ART during the perinatal period. Frequently women continue receiving ART from maternal and child health clinics through delivery, and sometimes through up to one year postpartum, before transitioning to receiving care in an adult ART clinic(22). Patients who do not return to the clinic where they are receiving their ART within 2 months of a scheduled appointment are expected to have run out of ART and are considered LTFU(20).

Currently, HIV visits among women in Option B+ are monitored using both an electronic medical record (EMR) system and paper-based registries, depending on the clinic. Medical record information should be linkable across clinics using the EMR via patient demographic characteristics and a patient's EMR number, which are recorded on patient's health passport (e.g. mobile medical record). However, in practice linking EMR records across clinics is challenging due to patients changing health passports and subsequently receiving multiple

EMR numbers, or registering for healthcare visits using different demographic information(11, 23).

Study design and sample

We conducted a pilot study to evaluate the feasibility and acceptability of using biometric fingerprint scanning to accurately identify women and register HIV visits at two large urban antenatal clinics in Lilongwe, Malawi. Both study clinics currently use an EMR system to register HIV visit attendance for women in Option B+. Between mid-October 2018 and mid-January 2019, we enrolled all eligible HIV-infected pregnant women receiving antenatal care who consented to participate, including women who were newly initiating ART, those already on ART, and women re-initiating ART in the current pregnancy. Women were eligible for inclusion if they were at least 18 years of age, lived in the Lilongwe District, and planned to remain living in the district for the duration of the pilot study (approximately 3 months). We also enrolled a secondary population of healthcare workers (HCWs) from a variety of roles at both clinics, including nurses, data associates, HIV testing counselors and community health workers. Feasibility and acceptability were assessed in exit interviews with a sample of HIV-infected women and HCWs, via data on biometric system performance, and by comparing visit information captured in the biometric and EMR systems. All participants provided written informed consent and ethical approval was provided by the University of North Carolina in the United States and the National Health Science Research Committee in Malawi.

Data collection

Women were sensitized to the aims of the study during a morning health talk, which occurs before the daily initiation of services at each study site. Women who were HIV-infected were identified by clinical staff and approached by a research assistant to evaluate their interest in participating in the study. Women who met eligibility criteria and provided informed consent were invited to enroll. At enrollment into the study, HIV-infected women were asked to register their fingerprint using a battery-powered, handheld biometric fingerprint scanner held by the research assistant and to complete a brief baseline questionnaire. Participants registered their left index finger, or in the event of damage to that finger, their right index finger. Biometric fingerprint scanners and the web-based application to register fingerprints were provided by Simprints, a UK-based biometric fingerprint not-for-profit company(24). Clinical and demographic data, including a woman's EMR number, were collected using a web-based data collection application called CommCare.

After scanning a participant's finger, a template for the scanned fingerprint, rather than the actual fingerprint image, was linked to each participant's questionnaire data using a unique identification number and Bluetooth technology to preserve patient privacy and data security. Once a participant had registered her fingerprint, she could swipe her finger at subsequent follow-up visits to record her HIV visit attendance. All biometric and questionnaire data were collected using handheld tablets and fingerprint scanners by research assistants who were trained over a two-week period. Biometric and questionnaire data were collected while tablets and scanners were offline (e.g. not connected to the internet) and uploaded and synced across study sites daily using wireless internet. Data was

stored in a single, centralized cloud-based location to allow identification of participants across the two study sites. HIV visit information for each participant during the study period that was recorded in the EMR used at both clinics was also collected.

To assess the feasibility and acceptability of using biometric fingerprint scanning to record HIV visits, we conducted exit interviews. Exit interviews comprised a brief questionnaire, conducted by a research assistant during the final month of the study with the sample of participants (n=145) presenting for care in the last month of the study and a sample HCWs (n=48). Exit interviews were not conducted with all participants at follow-up visits due to budget constraints. In addition, research assistants responsible for registering and recording HIV visits using biometric fingerprint scanning completed weekly evaluations of the biometric scanner performance and usability. Both exit interviews and weekly biometric evaluations contained closed (multiple choice or Likert scale response) and open-ended questions.

Data analysis

The goal of this pilot study was to assess feasibility and acceptability of using biometric fingerprint scanning to identify women and record HIV visits among women in Option B+. We assessed feasibility in three ways: 1) two exit interview questions assessing the perceived difficulty and assistance needed to use biometrics to identify women and record HIV appointments, 2) via data collected weekly on biometric system performance, and 3) by comparing concordance in HIV visits captured between the biometric and EMR systems during the pilot period. We assessed acceptability through four exit interview questions assessing participant satisfaction, comfort, overall impression, and whether their expectations were met using biometric fingerprint scanning.

Measures of feasibility and acceptability were evaluated descriptively and graphically. We compared sociodemographic and clinical characteristics between women who completed an exit interview and women who did not, as well as women who completed a follow-up visit and those who did not, to assess the potential for selection bias. All statistical analyses were conducted using Stata, version 15 (StataCorp, College Station, Texas).

Results

Participant characteristics

Of 423 eligible participants, we enrolled 314 HIV-infected pregnant women and 51 HCWs (86% participation), for a total of 365 participants (Figure 1). Of the 58 participants who declined to enroll in the study, none declined due to discomfort using biometric fingerprint scanning and the majority (n=37, 64%) declined for “Other” reasons (Figure 1). Anecdotally, study staff reported that the majority of these women declined to participate because they reported needing prior approval from their male partner. All enrolled participants successfully registered their fingerprint.

At enrollment, the median age among HIV-infected women was 28 (IQR 24, 32), the majority of women were married (95%), a housewife or caretaker (64%), and were multiparous (81%; Table 1). Overall, 39% of women were initiating ART for the first time

and 35% did not know their partner's HIV status. Most women (64%) had disclosed their status to their partner, but fewer (45%) had disclosed to a family or friend. Among the 61% of women already on ART, just 19% did not know their partner's HIV status, 88% had disclosed to their partner and 65% had disclosed to a family or friend.

HIV visit monitoring

Over the three-month pilot period, we recorded 433 visits (314 enrollment visits and 119 follow-up visits) among HIV-infected women using biometric fingerprint scanning. At follow-up visits, 8% of women reported a different EMR number, potentially leading to multiple health records per patient. The biometric system identified two potential duplicate participants; one of which was determined to be a duplicate and the other not a duplicate. No transfers between the two study clinics were identified among participants during the 3-month pilot period.

Of the 433 visits captured via biometric fingerprint scanning, 167 (39%) were captured in both the biometric and the EMR systems and 266 (61%) were recorded only in the biometric system. An additional 109 visits were recorded in only the EMR system, for a total of 542 visits. Of the 542 HIV visits captured during the study period in both the biometric and EMR systems, a total of 80% were recorded by the biometric system versus 51% in the EMR system (prevalence ratio [PR] 1.57, 95% CI 1.43, 1.72, p-value <0.05, kappa statistic -0.40; Figure 2). Visits captured in the EMR system-only were most common in late December and early January, and towards the end of the pilot period.

Among 314 enrolled HIV-infected women, 30% had a follow-up visit during the three-month study period. Among the 121 women initiating ART for the first time, who likely were asked to return for monthly HIV visits, only 35 (29%) had a follow-up visit during the 3-month pilot period (Table S1). Women with a follow-up visit during the study period were more likely to be <25 years of age (33% versus 26%), nulliparous (25% versus 17%), and to have disclosed their HIV status to their partner (71% versus 61%). Women who were initiating ART for the first time were no more or less likely to have a follow-up visit (37% versus 39%). Unfortunately, we were not able to identify when women missed scheduled HIV visits during the study period in our data.

Evaluation of Feasibility and Acceptability

Exit interviews were completed among 145 (46%) HIV-infected women who had visits in the final month of the study and 48 (94%) of HCWs (Figure 1). The overall feasibility and acceptability of using biometric fingerprint scanning to identify women and register HIV visits was high. The majority of participants felt biometrics was easy to use (64%), required no additional assistance (69%) and met their expectations (76%; Figure 3 and Table S2). In open-ended exit interview questions assessing what made biometric fingerprint scanning easy or difficult to use, 71% of respondents mentioned that it was "fast", "easy", or "not time consuming". Sociodemographic and clinical characteristics between HIV-infected women who completed an exit interview and those who did not were similar (Table S3), suggested women who completed exit interviews do not differ in meaningful ways from the larger study population.

When assessing biometric system performance, no major issues with data security, privacy, or scanner functionality were reported by participants or research assistants collecting data. In four instances across 2 clinics during the 13-week pilot period (4/26 weeks = 15% of the study period) research assistants were not able to scan a participant's finger due to scarring or wear on the participant's fingerprint. In those instances, participants were enrolled using an alternative finger (Table 2). In open-ended questions, research assistants identified the mobility and ease of use of the fingerprint scanners as their favorite features, and noted that intermittent internet connectivity occasionally affected the ability to sync data across study sites for a day or two.

Discussion

In this pilot evaluation, we found that using biometric fingerprint scanning was a feasible and acceptable method to identify women in Option B+ and monitor HIV visits. Both HIV-infected women and healthcare workers felt biometric fingerprint scanning was easy to use, worked reliably, and did not require a lot of additional assistance to operate. Importantly, no concerns related to data privacy and confidentiality for biometric data were reported among study participants. Over the study period, biometric fingerprint scanning captured significantly more study visits among women enrolled in Option B+ at our study clinics, compared to the current EMR system used to monitor HIV visits.

In our study, biometric fingerprint scanning out-performed the current EMR system in recording HIV visits among women in Option B+. During the 3-month study period, nearly 50% of HIV visits captured in the biometric system were not recorded in the current EMR system used to monitor HIV visits. In addition, 8% of women in our study population reported more than one EMR number during the study period. These findings suggesting that a sizeable portion of attended HIV visits may be missed by the current EMR-based monitoring system, and that some women with recorded visits may have multiple healthcare records. The EMR system may have missed visits due to power or system outages at the clinics. During such times, HIV visits are typically recorded in paper registries and should be entered into the EMR system once functionality is regained. However, we were unable to verify EMR system functionality or entering of missed visits during system or power outages into the EMR during the pilot period. Not recording attended HIV visits and having multiple records complicates efforts to monitor ART treatment programs and provide high-quality HIV care, particularly when patients transfer between clinics(10). For the 30% of women reported elsewhere to have transferred clinics during the perinatal period(12, 25), incomplete or inaccurate information on HIV visits may hinder continuity in HIV care and lead to gaps in ART access(11).

During the study period, the biometric system performed better than the EMR-based monitoring system, but still missed 20% of HIV visits. We collected weekly biometric performance information and were able to verify that the system was functioning during all working days. Visits captured in the EMR system-only were most common in late December and early January, when government clinics were primarily closed and study staff were on holiday break, or at the end of the study period when study staff may have been more focused on conducting exit interviews. In addition, research assistants responsible for

collecting biometric information were stationed at one location in each clinic and may have missed some participants who left the clinic without visiting study staff. These findings highlight the importance of integrating biometric fingerprint scanning into existing HIV monitoring systems in order to capture all visits attended and using biometrics at several points within a clinic (e.g. registration, pharmacy pickup, etc.) in order to accurately record patient engagement in care.

In our pilot study, biometric fingerprint scanning was a feasible and acceptable strategy to identify women and record HIV visits, which may help to support sustained engagement in care for women in the perinatal period. These findings aligns with previous work demonstrating the feasibility and acceptability of using biometric fingerprint scanning in sub-Saharan Africa to identify and monitor patient visits and link healthcare records in a variety of healthcare settings (16–18). Enrollment in the pilot study was 86% and participants reporting high levels of comfort, satisfaction and reliability with biometric fingerprint scanning.

In addition to participant and healthcare worker satisfaction with using biometrics, biometric fingerprint scanning had several characteristics that may make it a scalable strategy to monitor engagement in HIV care. For example, internet capabilities were available at each clinic in our study and used to upload data and sync across sites daily. However, for settings without internet, upload and syncing is feasible using cellular networks. Biometric fingerprint scanning also included the ability to collect data offline, required a short time period (two weeks) to train research assistants to use the biometric fingerprint scanners, has the potential to be integrated with existing data collection systems, such as electronic medical records, and is relatively low cost. Simprints provided biometric fingerprint scanners that integrated with the CommCare data collection platform at a reduced cost for the pilot study. However, in order to scale biometric fingerprint scanning up to a larger network of clinics, lower-cost strategies may need to be considered. For example, commercially available biometric fingerprint scanners and data hosting platforms, which could be paired (but are not currently integrated) with open-source data collection platforms, such as Open Data Kit, may be lower cost. Future research should explore the cost of scaling up biometric fingerprint scanning across a network of HIV clinics to inform policy choices in resource-limited settings.

Findings from our study should be interpreted in light of several limitations. Women entering ANC who are already on ART may not be asked to return for a visit for up to 90 days. Therefore, the 61% of women in the study population on ART may not have had a follow-up visit scheduled during the 3-month pilot period. While this may have limited the number of women on ART who completed an exit interview, we did not observe important differences in characteristics between women who did and did not complete an exit interview. We also note as limitations the inability to complete exit interviews with all women, verify EMR system functionality throughout the pilot period, and identify missed HIV visits among participants.

Conclusions

The transition to universal ART access for all HIV-infected pregnant and breastfeeding women under Option B+ has led to dramatic reductions in HIV incidence and improvements in maternal health. But to realize the gains of universal ART access, long-term engagement in HIV care for women in Option B+ is essential. Improving long-term engagement in HIV care is likely to require patient-level interventions to support ART adherence and retention. However, without parallel investment in scalable strategies to monitor engagement in HIV care across the health system, we may risk losing the ability to monitor ongoing engagement in care and support women in accessing care at the clinic of their choice. Among women completing exit interviews in this pilot study, biometric fingerprint scanning was a feasible and acceptable strategy to identify and monitor HIV visits for women in Option B+. Future studies should evaluate whether biometric fingerprint scanning can be scaled-up to a larger network of clinics and whether its implementation improves the ability to monitor HIV visits, identify women who have transferred clinics, and support sustained engagement in HIV care during the perinatal period for women in Option B+.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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List of Abbreviations

ANC	antenatal care
ART	Antiretroviral therapy
EMR	Electronic medical record
HIV	Human Immunodeficiency Virus
LTFU	Lost to follow-up

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Contributions to the literature

- Lifelong antiretroviral therapy for pregnant and breastfeeding women, known as Option B+, is an evidence-based intervention critical to improving maternal health and reducing vertical HIV transmission. For Option B+ to be successful, women need to remain engaged in HIV care.
- Current HIV monitoring systems are not well-equipped to monitor women's engagement in care across HIV clinics.
- We pilot tested biometric fingerprint scanning as a strategy to monitor HIV visits at two antenatal clinics in Malawi. Biometric fingerprint scanning was feasible, acceptable, and should be scaled-up and evaluated as a potential strategy to improve HIV monitoring and support sustained engagement in care.

Figure 1. Study participation among HIV-infected pregnant women enrolled in Option B+ and healthcare workers (HCW) in Lilongwe, Malawi.

Figure 2.

A total of 542 HIV visits among 314 HIV-infected women recorded with a) both the biometric fingerprints scanning and electronic medical record (EMR) system, B) just the biometric system, C) just the EMR system from October 2018-January 2019 at two large antenatal clinics in Lilongwe, Malawi.

Figure 3. Feasibility and acceptability of biometric fingerprint scanning to register HIV appointments among 193 HIV-infected women and healthcare workers who completed exit interviews. Number at the end of each bar represent the percentage of participants in that category.

Table 1.

Demographic and clinical characteristics of 314 HIV-infected pregnant women enrolled in Option B+ in two maternity centers in Lilongwe, Malawi.

	Site A N=215	Site B N=99	Total N=314
	Median (IQR)		
Age	27 (23, 32)	29 (25, 34)	28 (24, 32)
Gestational age at enrollment, completed weeks	13 (10, 23)	13 (10, 17)	13 (10, 23)
Gravidity	3 (3,4)	4 (3,5)	3 (3,4)
	N (%)		
Marital Status			
Married	204 (94.9)	95 (96.0)	299 (95.2)
Not married	11 (5.1)	4 (4.0)	15 (4.8)
Occupation			
Housewife/Caretaker	126 (58.6)	76 (76.8)	202 (64.3)
Small Business Owner	66 (30.7)	21 (21.2)	87 (27.67)
Other	23 (10.7)	2 (2.0)	25 (8.0)
Education			
No School	16 (7.4)	1 (1.0)	17 (5.4)
S1-S7	58 (27.0)	43 (43.4)	101 (32.2)
S8	29 (13.5)	26 (26.3)	55 (17.5)
Secondary or More	112 (52.1)	29 (29.3)	141 (44.9)
Residence			
Rural	18 (8.4)	1 (1.0)	19 (6.0)
Urban	197 (91.6)	99 (99.0)	295 (94.0)
Changes in residence in previous year			
0	200 (93.0)	66 (67.0)	266 (84.7)
1	15 (7.0)	33 (33.0)	48 (15.3)
Nulliparous			
No	164 (76.3)	90 (91.0)	254 (80.9)
Yes	51 (23.7)	9 (9.0)	60 (19.1)
Initiating ART for the first time			
No	115 (53.5)	78 (78.8)	193 (61.5)
Yes	100 (46.5)	21 (21.2)	121 (38.5)
Partner is HIV-infected			
No	87 (40.5)	31 (31.3)	118 (37.6)
Yes	50 (23.3)	35 (35.4)	85 (27.1)
Don't Know	78 (36.3)	33 (33.3)	111 (35.3)
Disclosure to partner			
No	92 (42.8)	20 (20.2)	112 (35.7)
Yes	123 (57.2)	89 (79.8)	202 (64.3)

	Site A N=215	Site B N=99	Total N=314
Disclosure to a family member or friend			
No	129 (60.0)	42 (42.4)	171 (54.5)
Yes	86 (40.)	57 (57.6)	143 (45.5)
Taken ART in a previous pregnancy (among 254 multiparous women)			
No	158 (96.3)	61 (67.8)	219 (86.2)
Yes	6 (3.7)	29 (32.2)	35 (13.8)

Table 2.

Biometric scanner performance by site and overall, aggregated over 13 weeks during the pilot study period

	Site A N=13	Site B N=13	Combined N=26
Was the scanner useable?			
Yes	13 (100.0)	13 (100.0)	26 (100.0)
No	0 (0.0)	0 (0.0)	0 (0.0)
Was the scanner mobile?			
Yes	13 (100.0)	13 (100.0)	26 (100.0)
No	0 (0.0)	0 (0.0)	0 (0.0)
Did the scanner break?			
Yes	0 (0.0)	0 (0.0)	0 (0.0)
No	13 (100%)	13 (100%)	26 (100%)
Did the scanner battery last all day?			
Yes	13 (100.0)	13 (100.0)	26 (100.0)
No	0 (0.0)	0 (0.0)	0 (0.0)
Were you able to scan fingerprints easily?			
Yes	10 (76.9)	12 (92.3)	22 (84.6)
No	3 (33.1)	1 (7.7)	4 (15.4)
Any other Concerns?			
No	13 (100.0)	13 (100.0)	26 (100.0)
Other	0 (0.0)	0 (0.0)	0 (0.0)