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The FAST-M complex intervention for the detection and management of maternal sepsis in low-resource settings: a multi-site evaluation

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Shortened running title: FAST-M maternal sepsis complex intervention

Abstract

Objective: To evaluate whether the implementation of the FAST-M complex intervention was feasible and improved the recognition and management of maternal sepsis in a low-resource setting.

Design: A before and after design.

Setting: Fifteen government healthcare facilities in Malawi.

Population: Women suspected of having maternal sepsis.

Methods: The FAST-M complex intervention consisted of the following components: i) the FAST-M maternal sepsis treatment bundle and ii) the FAST-M implementation programme. Performance of selected process outcomes were compared between a two month baseline phase and six month intervention phase with compliance used as a proxy measure of feasibility.

Main outcome result: Compliance with vital sign recording and use of the FAST-M maternal sepsis bundle.

Results: Following implementation of the FAST-M intervention, women were more likely to have a complete set of vital signs taken on admission to the wards (0/163 (0%) vs. 169/252 (67.1%), $p<0.001$). Recognition of suspected maternal sepsis improved with more cases identified following the intervention (12/106 (11.3%) vs. 107/166 (64.5%), $p<0.001$). Sepsis management improved, with women more likely to receive all components of the FAST-M treatment bundle within one hour of recognition (0/12 (0%) vs. 21/107 (19.6%), $p=0.091$). In particular women were more likely to receive antibiotics (3/12 (25.0%) vs. 72/107 (67.3%), $p=0.004$) within one hour of recognition of suspected sepsis.

Conclusion: Implementation of the FAST-M complex intervention was feasible and led to the improved recognition and management of suspected maternal sepsis in a low-resource setting such as Malawi.

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Keywords: Maternal sepsis, low-resource setting, feasibility study, complex intervention, care bundle.

Tweetable Abstract: Implementation of a sepsis care bundle for low-resources improved recognition & management of maternal sepsis

Introduction

Maternal sepsis is defined as “organ dysfunction resulting from infection during pregnancy, child-birth, post-abortion, or the post-partum period”.¹ Globally it is the third most common direct cause of maternal mortality accounting for 11% of deaths and disproportionately impacting low-resource settings within low- and middle- income countries (LMICs).² Reducing the burden of maternal sepsis in low-resource settings has been identified as a global health priority.³ In 2015, the World Health Organization (WHO) and Jhpiego launched the Global maternal and neonatal sepsis initiative^{4,5} with the aim of developing and testing strategies to improve the recognition and management of maternal sepsis.

Early recognition and timely initiation of sepsis treatment have both been shown to improve outcomes.⁶⁻¹¹ Use of sepsis screening tools and treatment bundles can reduce time to treatment initiation^{12,13} and have been widely adopted in high-resource settings.^{14,15} To date there is no sepsis care bundle that is specific to the maternity population and can be reliably implemented in a low-resource setting.¹⁶⁻¹⁸

Using a modified Delphi process to engage a wide range of healthcare practitioners from a range of LMICs, as well as an expert panel, a clinically relevant maternal sepsis care bundle was developed through international consensus.¹⁹ The resultant maternal sepsis care bundle, which was called ‘FAST-M’ to aid with practitioner recall, consisted of the following components: Fluids, Antibiotics, Source identification and control, Transfer to an appropriate level of care, and ongoing Monitoring of mother and neonate. In-country meetings were held in Malawi to further operationalize the bundle and develop the FAST-M complex intervention.

The aim of this feasibility study was to evaluate whether the implementation of the FAST-M complex intervention for the recognition and management of maternal sepsis was feasible and resulted in an improvement in clinical care within a low-resource setting. The results of this study will inform optimisation of this approach and future clinical trials to determine its clinical effectiveness.

Methods

We conducted a before and after study at fifteen government healthcare facilities in Malawi between June 2017 and March 2018. Study sites clustered into three hubs, each containing either a district or community hospital and four health centres. Each health centre directly referred patients to the hospital in its hub. The eligible participants were all women who were pregnant or within six weeks of miscarriage, termination of pregnancy or child birth (irrespective of outcome) and who were receiving either inpatient or outpatient health care. There were no exclusion criteria.

Intervention

The FAST-M complex intervention is described fully in the Supplementary files (Appendix S1). Briefly, the intervention consisted of the following components: i) a modified early obstetric warning system (MEOWS) chart and the FAST-M decision tool, ii) the FAST-M maternal sepsis care bundle, and iii) the FAST-M implementation programme. Figure 1 illustrates the components of the FAST-M intervention. No patients were involved in the development of the intervention.

Figure 1: FAST-M complex intervention.

Component 1 – MEOWS chart and FAST-M decision tool

The MEOWS chart (Figure 2a) supported healthcare practitioners to ensure vital signs were recorded regularly in all women, and thus to identify women at risk of clinical deterioration. The presence of abnormal vital signs prompted healthcare practitioners to screen for maternal sepsis using the FAST-M decision tool. The FAST-M decision tool (Figure 2b) guided healthcare practitioners to differentiate between those with features of suspected maternal sepsis, those with a maternal infection which had not yet developed into sepsis, and those with abnormal vital signs due to another cause. The distinction between those with maternal sepsis and a maternal infection was based on the degree of derangement in the vital signs.

Component 2 – FAST-M maternal sepsis care bundle

Women deemed to have suspected maternal sepsis were commenced on the FAST-M care bundle (Figure 2c), with the aim to initiate all components of the bundle within an hour of sepsis recognition.

Figure 2a-c: FAST-M toolkit; (a) Modified Early Obstetric Warning Score chart, (b) FAST-M decision tool and (c) FAST-M maternal sepsis care bundle.

Component 3 -The FAST-M implementation programme

The implementation programme consisted of the following; FAST-M training programme and refresher training, sepsis champions, task shifting, performance dashboards and data feedback.

All healthcare practitioners and non-clinical staff working in the maternity and female wards at the healthcare facilities attended the FAST-M training programme (Appendix S1). Training was delivered in hubs and took the form of interactive workshops and group-based scenarios based on improving the recognition of maternal sepsis and the use of the MEOWS charts and FAST-M tools. The training was delivered in English with a local Malawian from the study team present to translate into Chichewa if required.

Healthcare practitioners demonstrating enthusiasm and capacity were recruited as maternal sepsis champions for the intervention as well as key members of the senior leadership. Sepsis champions acted as advocates for the study and were responsible for providing day to day oversight of healthcare practitioner practice. Task shifting was introduced to address issues associated with staff shortages and the resultant delays to patient care. Firstly, patient attendants, whose day to day roles typically included the general cleaning of wards, assisting patients to clean and eat and assisting clinical staff when required, were trained to take and record vital signs on the observation charts, to recognise abnormal recordings and escalate them to the nursing or midwifery staff. Additionally, nursing staff were empowered to initiate maternal sepsis treatment using the FAST-M treatment tool whilst awaiting a review from a clinician. Ad-hoc on-site refresher training was delivered by the study team and sepsis champions when required. During months one, three and six of the intervention phase departmental meetings were held during which site performance data in the form of performance dashboards were presented to staff.

Study period

The study comprised of a two month baseline phase during which usual practice was assessed. The FAST-M training programme was then delivered over a period of one month followed by a six month intervention phase to assess any change in practice.

Outcomes

Primary process outcomes included: the proportion of inpatients receiving a full set of vital signs on admission to the ward and the proportion of women with suspected maternal sepsis receiving the full FAST-M bundle (and each of the individual bundle components) within one hour of recognition of sepsis.

Secondary outcomes included; the proportion of women with suspected maternal sepsis escalated to senior healthcare practitioners on the basis of abnormal vital signs and the proportion of women with suspected maternal sepsis who received a clinical review by a senior clinical decision maker following their diagnosis. No core outcome set was used.

Data Collection

Data were captured by local data collectors using a review of patient case notes. Selected process outcomes were captured electronically using the CommCare data capture platform. Healthcare practitioner performance of vital signs was captured at months 1 and 2 of the baseline phase and months 1, 3 and 6 of the intervention phase. Data collectors made unscheduled visits to each of the 15 sites with no prior notice given to the sites of their arrival. During these visits a random sample of patient notes were retrospectively reviewed with data collectors given two hours at each site to review as many inpatient notes as possible. Healthcare practitioner management of all cases of suspected maternal sepsis was captured continuously. Informed written consent was obtained from all women prior to a member of the study team accessing their notes.

Statistical analysis

Relevant study outcomes were collected to enable the comparison of clinical practice before and after the introduction of the FAST-M intervention. The performance of each clinical procedure was described by the use of proportions. Performance during the six month intervention phase was tested overall versus the baseline using a chi-squared test for independence. A chi-squared test for trend (p trend) was conducted to evaluate whether performance during the intervention phase was maintained.

Statistical significance was determined at $p < 0.05$. Statistical analyses were performed using Stata statistical software, release 15 (StataCorp, College Station, TX, 2017).

Role of funding source

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Results

During the evaluation of the FAST-M intervention 12,753 inpatients were admitted to the maternity wards. Of those, 415 inpatients (163 women during the baseline and 252 women during the intervention), had their records examined to assess whether their vital signs had been taken on admission to the wards.

Following the implementation of the FAST-M intervention, women were more likely to have a complete set of vital signs taken on admission to the maternity wards compared to the baseline phase (0/163 (0%) vs. 169/252 (67.1%), $p<0.001$) (Figure 3a-b). Improvements were seen across the measurement of all vital sign variables; respiratory rate (9/163 (5.5%) vs. 190/252 (75.4%), $p<0.001$), temperature (60/163 (36.8%) vs. 222/252 (88.1%), $p<0.001$), heart rate (45/163 (27.6%) vs. 225/252 (89.3%), $p<0.001$), blood pressure (60/163 (36.8%) vs. 229/252 (90.9%), $p<0.001$), urine output (10/163 (6.1%) vs. 193/252 (76.6%), $p<0.001$) and neurological assessment (86/183 (52.8%) vs. 217/252 (86.1%), $p<0.001$). Fetal heart rate was comparatively well recorded before the intervention, so the improvement in recording of this variable was small (21/31 (67.7%) vs. 54/72 (75.0%), $p=0.448$). The improvements seen across all individual parameters were maintained for the duration of the intervention with no significant deterioration in performance observed over time. Performance of a complete set of vital signs was not only maintained throughout the intervention but demonstrated a continued improvement over time (p trend=0.001). This trend towards continued improvement over time was also seen across the measurement of individual parameters including respiratory rate (p trend=0.012), urine output (p trend<0.001) and neurological assessment (p trend<0.001).

Figure 3a-b: Completion of vital signs when first assessed as an inpatient on the maternity wards.

A total 119 women with suspected maternal sepsis were identified during the study; 12 during the baseline phase and 107 during the intervention phase. Patient demographics are presented in Table S1. Following the implementation of the FAST-M intervention, the identification of cases of suspected maternal sepsis increased as a proportion of the total number of maternal infection cases during the study (12/106 (11.3%) vs. 107/166 (64.5%), $p<0.001$).

Following the implementation of the FAST-M intervention, women being treated for suspected maternal sepsis were more likely to receive all components of the FAST-M treatment bundle within one hour of recognition of suspected sepsis (0/12 (0%) vs. 21/107 (19.6%), $p=0.091$) (Figure 4a-b). Improvements in sepsis management were seen across all components of the FAST-M treatment bundle with women more likely to receive intravenous fluid therapy (3/12 (25.0%) vs. 59/107 (55.1%), $p=0.048$), intravenous antibiotics (3/12 (25.0%) vs. 72/107 (67.3%), $p=0.004$), source identification (6/12 (50.0%) vs. 73/107 (68.2%), $p=0.205$), consideration for transfer (0/12 (0%) vs. 47/107 (43.9%), $p=0.003$) and on-going monitoring (7/12 (58.3%) vs. 79/107 (73.8%), $p=0.256$) within one hour of sepsis recognition. The

improvements seen in the treatment of women with suspected maternal sepsis were maintained for the duration of the intervention with no significant deterioration in performance observed over time (all p trend=0.909, fluids p trend=0.870, antibiotics p trend=0.572, source identification p trend=0.712, consideration of transfer p trend=0.517 and on-going monitoring p trend=0.445).

Women with suspected maternal sepsis were more likely to be escalated to senior healthcare practitioners on the basis of their abnormal vital signs, following the implementation of the FAST-M intervention (10/12 (83.3%) vs. 104/107 (97.2%), $p=0.02$). Similarly, women were more likely to receive a clinical review by a senior clinical decision maker following their diagnosis of suspected maternal sepsis (8/12 (75.0%) vs 103/107 (96.3%), $p<0.001$).

Figure 4a-b: Completion of FAST-M bundle within one hour of recognition of maternal sepsis.

Discussion

Main Findings

Introduction of the FAST-M complex intervention resulted in an improvement in clinical care for women with suspected maternal sepsis. Following its implementation, women were more likely to receive a full set of vital signs on admission. Improvements were seen across all vital sign parameters. Healthcare practitioners' recognition of maternal sepsis also improved with more cases of suspected sepsis likely to be escalated to senior clinical decision makers. Improvements in sepsis management were seen across all components of the FAST-M treatment bundle; in particular the proportion of women receiving antibiotics within one hour of sepsis recognition.

Strengths and Limitations

Implementation of the FAST-M intervention was evaluated in low-resource settings, across a wide range of government healthcare facilities increasing the generalisability of the findings. Sites varied in the number of sepsis cases seen, size of maternity departments, healthcare staff employed and resources available.

The study had a number of limitations. The before and after design was chosen to enable all sites to participate fully in the intervention and was a suitable design to evaluate programme feasibility across a range of facilities. However, such a design cannot account for temporal trends and is prone to reporting and selection bias. The results may be explained by a possible Hawthorn effect whereby close monitoring of study sites, may have prompted staff to be more compliant with the intervention. Similarly a temporal change or changes to patient population over time may have contributed to the results seen. The large effect sizes however, suggest these explanations are unlikely. Whilst a before and after design is at increased risk of bias compared to a robust cluster randomised design, this was a pragmatic choice to enable the rapid and

efficient conduct of the study as part of the development process for the FAST-M intervention. Future studies seeking to determine intervention effectiveness should adopt a cluster randomised design to reduce such risks of bias. The infrequent vital sign monitoring prior to the implementation of the intervention meant that only a small number of suspected maternal sepsis cases were identified in the baseline phase. Without evidence of deranged vital signs, we were unable to differentiate cases of suspected maternal sepsis during the baseline from those of maternal infections. As such, some potential suspected sepsis cases were likely coded as maternal infections due to missing vital signs. This limited the ability to demonstrate differences between the baseline and intervention phases.

Interpretation

Early recognition of patients with sepsis is critical to ensuring timely management and improved maternal outcomes.^{7,20} Use of MEOWS charts has been shown to predict severe maternal morbidity and mortality and to be associated with improved health outcomes.²¹ We found that the use of paper-based MEOWS charts combined with staff training and task shifting meant vital signs were more frequently measured and recorded. In addition, escalation of abnormal vital signs to senior healthcare practitioners increased, meaning women at risk of deterioration were more likely to be identified earlier and screened for sepsis.

In low-resource settings, poor sepsis recognition and lack of screening protocols can act as barriers to prompt identification and treatment.^{22,23} Use of sepsis screening tools has been shown to reduce time to treatment initiation,^{12,13} and a paediatric sepsis triage protocol in Malawi was shown to reduce in-hospital mortality.²⁴ In combination with the FAST-M implementation approach, use of the FAST-M decision tool helped streamline maternal sepsis identification and guide healthcare practitioners to make correct diagnoses.

Care bundles are the main focus of sepsis improvement initiatives in high-resource settings.^{25–29} Use of a sepsis bundle can reduce mortality,^{8,30} however bundle effectiveness is reliant on high levels of compliance.⁸ Studies conducted in high-resource settings have struggled to achieve high levels of bundle compliance, with total bundle compliance typically ranging between 10-43%.^{6,31–35} Internationally, the most widely recognised sepsis care bundle is the Surviving Sepsis Campaign's (SSC) sepsis bundle.^{25,26} Use of the SSC bundle across 218 hospitals in Europe, South America and the United States reduced sepsis-related mortality rates, with overall mortality lower in sites with higher bundle compliance.⁹ Similar results were observed across 62 countries where high SSC bundle compliance led to a 36% reduction in mortality (OR 0.64; 95% CI, 0.47-0.87).¹¹ No existing sepsis bundles can reliably be implemented in low-resource settings^{36,37} as lack of key resources including blood culture sets and laboratory facilities, limit compliance.^{16–18} A continent-wide survey of sepsis resource availability in Africa revealed only 1.5% of facilities surveyed could implement the SSC bundle in its entirety.¹⁷ Our study demonstrated that the

introduction of the FAST-M maternal sepsis bundle was feasible in a low-resource setting and resulted in improved levels of care. Following the intervention, all components of the FAST-M treatment bundle were more reliably completed within an hour, however the limited documentation of vital signs during the baseline underreported suspected sepsis cases and limited the power of before and after comparisons.

Timely initiation of antibiotics is the cornerstone of sepsis management with early administration shown to improve patient outcomes and mortality.^{7,38-40} A retrospective analysis of 35,000 septic patients, demonstrated an adjusted mortality odds ratio of 1.09 (95% CI, 1.00-1.19, $p=0.046$), based on each hour delay in antibiotic administration, with an increase in absolute mortality for each hour delay of 0.3% (95% CI; 0.01-0.6%, $p=0.04$) in sepsis and 1.8% (95% CI; 0.8-3.0%, $p=0.001$) in septic shock.³⁸ Similar findings from a retrospective analysis of 40,000 sepsis cases demonstrated that delay in antibiotic administration was associated with a higher risk of in-hospital mortality (odds ratio 1.04 per hour; 95% CI, 1.03-1.06, $p<0.001$).⁷ As a result of the FAST-M intervention, time to antibiotic administration in cases of suspected maternal sepsis decreased, with women more likely to receive antibiotics within an hour of sepsis recognition. We anticipate that the earlier administration of antibiotics demonstrated in this study could lead to improved outcomes, with associated reductions in sepsis-related mortality. There are examples within the global health literature of complex interventions that have failed to demonstrate significant differences in morbidity and mortality despite demonstrating large changes in process outcomes.⁴¹ We are therefore cautioned by these and are aware of the need to also consider the wider system-level determinants of health outcomes.

Following the introduction of the FAST-M intervention, women with suspected maternal sepsis were more likely to be reviewed by a senior clinical decision maker. This clinical review enabled initial treatment to be reviewed with on-going management tailored according to the woman's initial response. Lack of initial improvement triggered clinicians to consider the need to transfer the woman to a better resourced facility.

Improvements in both the performance of vital signs and treatment of patients with maternal sepsis were maintained throughout the intervention. Whilst this was encouraging, we are cautious to state that this is a clear demonstration of the intervention's sustainability. To formally evaluate sustainability, an extended period of assessment would be required, including how sites performed with less input from the study team.

The evaluation of the feasibility of the FAST-M intervention is an attempt to answer the WHO's and Jhpiego's call to develop and test strategies to improve the recognition and management of maternal sepsis.^{4,5} Conducting a feasibility study prior to a full-scale trial is in line with recommendations of the UK Medical Research Council for the evaluation of complex interventions,⁴² and is considered a key design and evaluation element to increase the likelihood of successful implementation when scaling up for larger trials.⁴²

In addition to these data, a detailed qualitative evaluation (to be published separately) was undertaken to describe key barriers and facilitators to implementation, and enable further optimisation of the approach. Detailed feedback obtained following the conclusion of the study enabled the tools to be further refined (Appendix S2).

Conclusion

Implementation of the FAST-M intervention, which sought to improve the recognition and management of maternal sepsis in a low-resource setting, was not only feasible but also resulted in improved clinical care. Future work will scale up the intervention for a multi-country intervention trial to determine intervention effectiveness.

Disclosure of Interests

Dr Cheshire reports grants from MSD for Mothers, University of Birmingham and from Ammalife during the conduct of the study. The other authors declare no competing interests. Completed disclosure of interest forms are available to view online as supporting information.

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Contributors

JC, DL, LM, CM, WPS, AJD, BN, AM, HMW, AW, IG, LJ and AC conceived the research project. DL led the research team. JC, WPS, LM, BN, HL, CK, TP and DL delivered the intervention. JC, LM, CK, HL, TP, CD and LJ participated in the data collection. JC, AJD, CD, AT analysed the data. JC, DL, LJ, IG and AC interpreted the findings. JC wrote the first draft, revised subsequent drafts and prepared the manuscript. All authors contributed equally to the revision of the manuscript and approved the final version of the paper. JC coordinated the contributors.

Details of Ethics Approval

Ethics approval to undertake this work was granted by the University of Birmingham's research ethics team (ERN_16-1168; date of approval 22/10/15). Ethics approval was granted by the University of Malawi's College of Medicine Research and Ethics Committee (COMREC) (P.02/17/2112; date of approval 10/05/2017).

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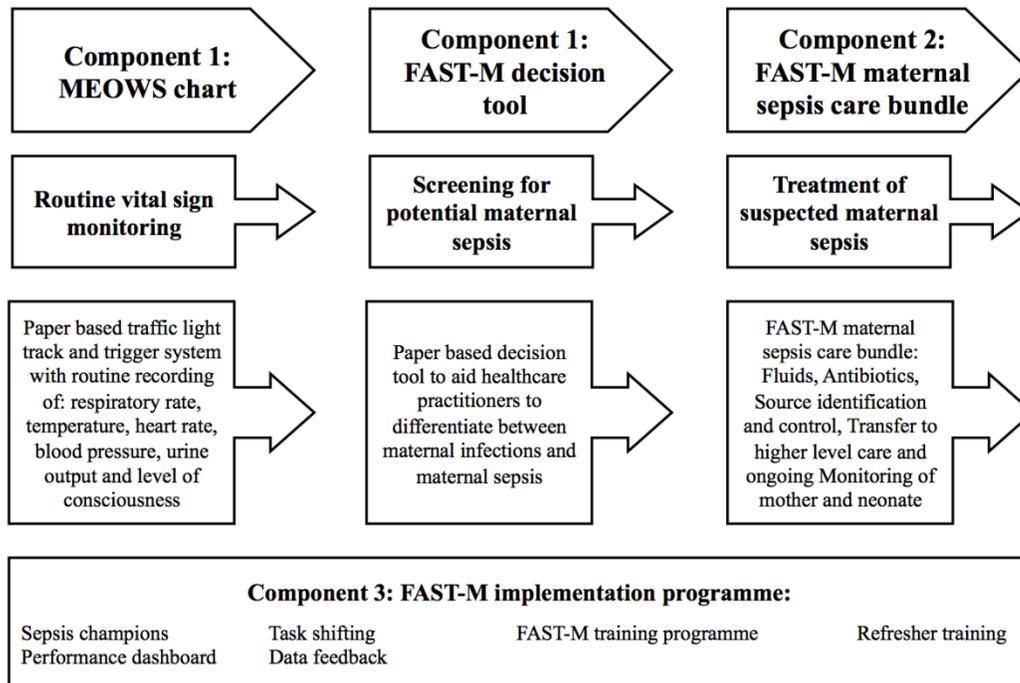
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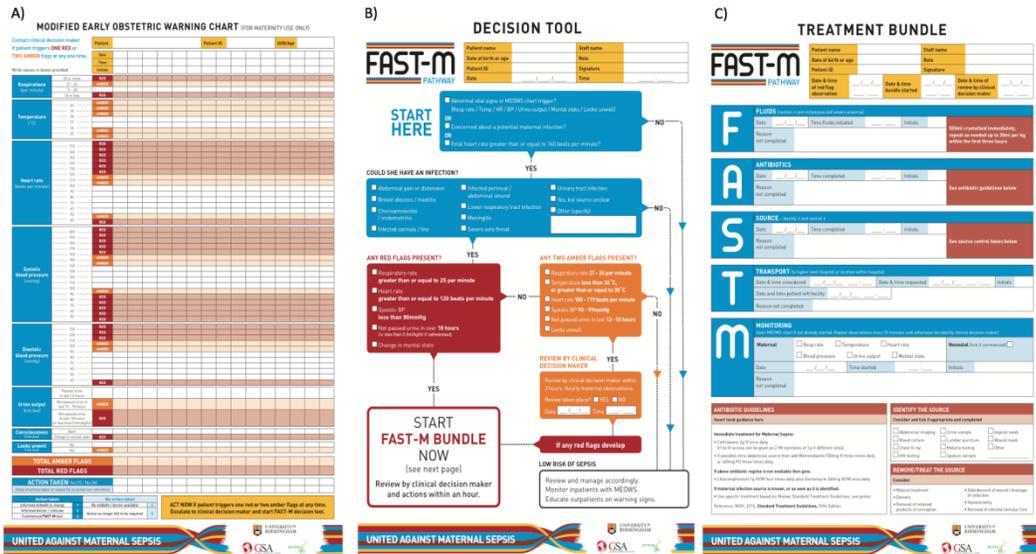
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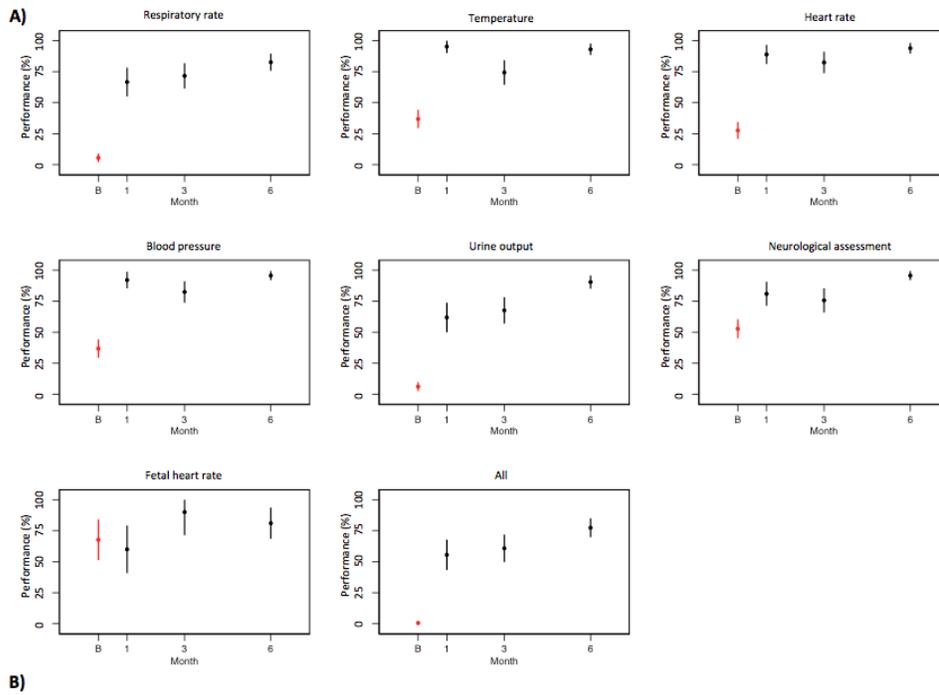
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- Shareable link to the video



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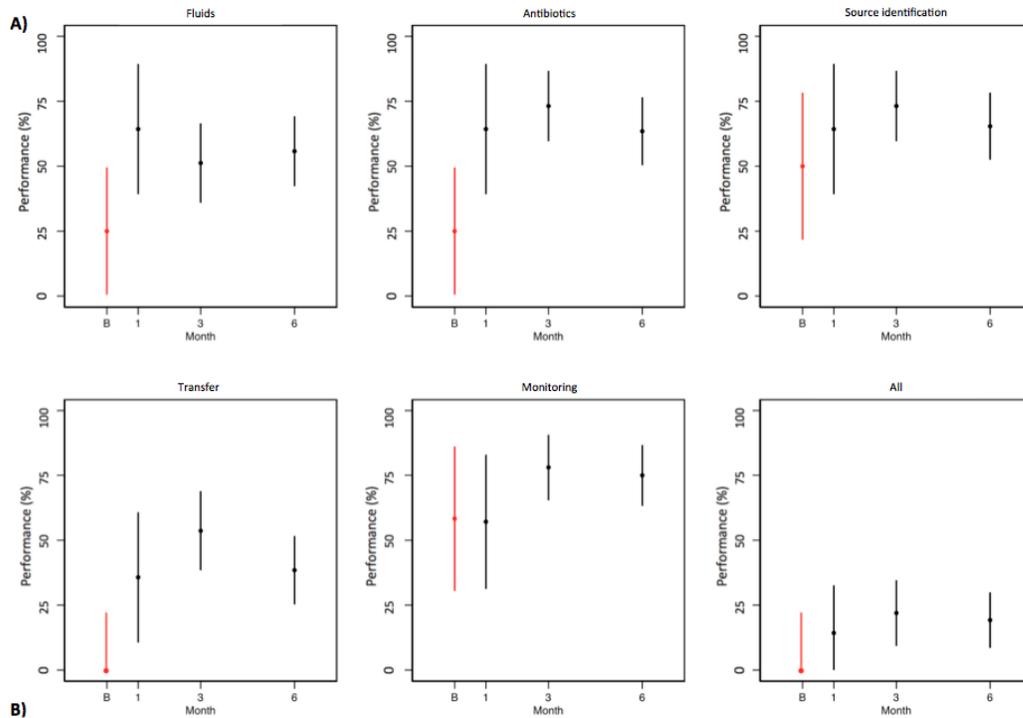
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	Baseline		Intervention Phase						P value	P trend
	n	%	Month 1		Month 3		Month 6			
All	0/163	0	35/63	55.6	45/74	60.8	89/115	77.4	<0.001	0.001
<i>Respiratory rate</i>	9/163	5.5	42/63	66.7	53/74	71.6	95/115	82.6	<0.001	0.012
<i>Temperature</i>	60/163	36.8	60/63	95.2	55/74	74.3	107/115	93.0	<0.001	0.453
<i>Heart rate</i>	45/163	27.6	56/63	88.9	61/74	82.4	108/115	93.9	<0.001	0.109
<i>Blood pressure</i>	60/163	36.8	58/63	92.1	61/74	82.4	110/115	95.7	<0.001	0.117
<i>Urine output</i>	10/163	6.1	39/63	61.9	50/74	67.6	104/115	90.4	<0.001	<0.001
<i>Neurological assessment</i>	86/163	52.8	51/63	81.0	56/74	75.7	110/115	95.7	<0.001	<0.001
<i>Fetal heart rate</i>	21/31	67.7	15/25	60.0	9/10	90.0	30/37	81.1	0.448	0.094

Data expressed as number and percentages. P values are shown for comparison of the baseline and intervention phase of FAST-M intervention, calculated by means of the chi-square test. P trend values are shown for the comparison of performance in months 1, 3 and 6 of the intervention phase, calculated by means of the chi-square test.

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B)

	Baseline		Intervention Phase						P value	P trend
	n	%	Month 1		Month 3		Month 6			
Total bundle	0/12	0	2/14	14.3	9/41	22.0	10/52	19.2	0.091	0.909
<i>Fluids</i>	3/12	25.0	9/14	64.3	21/41	51.2	29/52	55.8	0.048	0.870
<i>Antibiotics</i>	3/12	25.0	9/14	64.3	30/41	73.2	33/52	63.5	0.004	0.572
<i>Source identification</i>	6/12	50.0	9/14	64.3	30/41	73.2	34/52	65.4	0.205	0.712
<i>Transfer to higher level care</i>	0/12	0	5/14	35.7	22/41	53.7	20/52	38.5	0.003	0.517
<i>Monitoring</i>	7/12	58.3	8/14	57.1	32/41	78.0	39/52	75.0	0.256	0.445

Data expressed as number and percentages. P values are shown for comparison of the baseline and intervention phase of FAST-M intervention, calculated by means of the chi-square test. P trend values are shown for the comparison of performance in months 1, 3 and 6 of the intervention phase, calculated by means of the chi-square test.

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