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# Interprofessional teamwork for managing medical deterioration in pregnancy: what contributes to good clinical performance in simulated practice?

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## ABSTRACT

**Objectives** To identify the patterns of teamwork displayed by interprofessional teams during simulated management of medical deterioration in pregnancy and examine whether and how they are related to clinical performance in simulated practice.

**Design** Exploratory observational cohort study.

**Setting** Interprofessional clinical simulation training with scenarios involving the management of medical deterioration in pregnant women.

**Participants** Seventeen simulated scenarios involving 62 qualified healthcare staff working within the National Health Service attending clinical simulation training (midwives (n=18), obstetricians (n=24) and medical physicians (n=20)).

**Main outcome measure(s)** Teamwork behaviours over time, obtained through detailed observational analysis of recorded scenarios, using the Temporal Observational Analysis of Teamwork (TOAsT) framework. Clinician rated measures of simulated clinical performance.

**Results** Scenarios with better simulated clinical performance were characterised by shared leadership between obstetricians and midwives at the start of the scenario, with obstetricians delegating less and midwives disseminating rationale, while both engaged in more information gathering behaviour. Towards the end of the scenario, better simulated clinical performance was associated with dissemination of rationale to the team. More delegation at the start of a scenario was associated with less spontaneous sharing of information and rationale later in the scenario. Teams that shared their thinking at the start of a scenario continued to do so over time.

**Conclusions** Teamwork during the opening moments of a clinical situation is critical for simulated clinical performance in the interprofessional management of medical deterioration in pregnancy. Shared leadership and the early development of the shared mental model are associated with better outcomes.

## INTRODUCTION

Teamwork is a critical component of effective healthcare. The treatment and management of a hospital inpatient are rarely achievable by one individual but rely on the expertise and skills of multiple specialty doctors, nurses, midwives and many other allied health professionals to work as a cohesive, interprofessional team. Although the importance of teamwork for high quality care is

## What is already known on this subject

- ▶ Managing medical deterioration in pregnancy requires healthcare providers from different professional backgrounds (eg, midwives, obstetricians and medical physicians) to work together as a team to save two lives.
- ▶ Poor interprofessional teamworking and communication are a leading cause of maternal deaths following medical deterioration in pregnancy.
- ▶ Research suggests that leadership and having a shared mental model contribute to successful management of medical deterioration, yet little is known about how teamwork unfolds over time or how the actions of one team member may influence subsequent teamworking or how patient care is delivered.

## What this study adds

- ▶ Shared leadership, and development of the shared mental model at the very start of the clinical interaction were associated with better team simulated performance, suggesting that these behaviours were associated with teams working together effectively.
- ▶ Delegation at the start of a scenario was associated with poorer clinical performance in simulated practice.
- ▶ Overall, the type of leadership behaviour displayed in the opening moments of a clinical interaction was related to the subsequent teamwork, and to the effective simulated clinical performance of that team; these findings develop our understanding of the temporal dynamics of teamwork in complex clinical scenarios and provide evidence to inform current educational training and future definitive studies testing cause and effect relationships.

well recognised,<sup>1,2</sup> evidence suggests that interprofessional working may be challenging,<sup>3-5</sup> and the absence of effective interprofessional teamwork can compromise patient safety.<sup>2,6-9</sup>

Teamwork is particularly important in the care of pregnant women with coexisting medical



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conditions. A recent report, Mothers and Babies: Reducing Risk through Audits and Confidential Enquiries (MBRRACE), found that the majority of UK maternal deaths are ‘*in-direct deaths*’ occurring due to pre-existing or new-onset medical conditions (eg, neurological or cardiac diseases), rather than directly related to pregnancy (eg, pre-eclampsia).<sup>10–12</sup> The successful management of medical deterioration in a pregnant woman requires multiple sources of expertise and healthcare providers from different professional backgrounds (eg, midwives, obstetricians and medical physicians) working together as a team to manage a potentially life-threatening situation and save two lives. These professional groups do not routinely work together but must form a cohesive interprofessional team during such rare but critical situations. Numerous recent reports, including MBRRACE,<sup>10–12</sup> specifically identify poor interprofessional teamworking and communication as leading causes of maternal death in such situations.<sup>10–15</sup> As such, improving teamwork in this specific context is a requirement for improving patient care and reducing maternal death.

Improving teamwork requires in-depth knowledge of which aspects of teamwork are most effective for ensuring good team outcomes. Theoretical teamwork models suggest that successful teamwork requires effective leadership, development of shared mental models, adaptability, backup behaviour, team orientation and mutual performance monitoring.<sup>16</sup> Two studies have conducted video analysis observations of teamwork in the management of emergencies in pregnancy. However, both have focused on emergencies directly related to the pregnancy (ie, postpartum haemorrhage<sup>17</sup> and pre-eclampsia<sup>18</sup>) rather than medical deterioration due to pre-existing or new medical conditions (eg, asthma or epilepsy). Observational analysis of real-world incidents of postpartum haemorrhage suggest that effective leadership is a critical predictor of performance.<sup>17</sup> Analysis of simulated scenarios involving pre-eclampsia suggest that teams that take time to coordinate and share the mental model of the problem and the actions required have better simulated outcomes.<sup>18</sup> These studies have analysed teamwork as a static phenomenon, assigning a total score for the whole team. Such studies confirm the importance of leadership and developing a team shared mental model, but do not provide details of how team members interact and coordinate their work.

In this study, we used a novel analytical technique to analyse teamwork as it unfolds temporally. Teamwork is dynamic, evolving over the course of an interaction. The demands of clinical care unfold temporally, and so clinical teamwork must also have a temporal aspect. Teamwork is achieved by team members acting both individually and in response to others’ behaviour moment to moment, while responding to the fluctuating demands of patient care. Examining teamwork as it unfolds over a clinical episode is important for understanding how teams coordinate and interact. However, temporal dynamics in organisational teamwork has received relatively little research investigation to date.<sup>19</sup>

Conducting a fine-grained analysis of how interprofessional teams manage medical deterioration in pregnant women, due to a new or pre-existing medical condition, is needed to identify the specific behaviours used in this context, and their corresponding temporal patterns. This requires detailed analysis of video recordings of clinical care using interaction analysis research methods.<sup>19</sup> Previous studies have conducted such analyses in the context of anaesthesia and surgery. For example, in anaesthesia, observational analysis of simulated anaesthesia scenarios identified that speaking up behaviours, team monitoring and development of shared mental models predicted team

**Table 1** Scenario topics and the essential clinical actions to be performed during simulated practice

Scenario topic (n) Year recorded (n)	Essential clinical actions to be performed
<b>Sepsis (n=5)</b> 2015 (n=3), 2019/2020 (n=2)	<ol style="list-style-type: none"> <li>1. ABCDE assessment of pregnant woman</li> <li>2. Recognition of sepsis and septic shock</li> <li>3. Risk stratification and senior escalation</li> <li>4. Referral to Intensive Care Unit</li> <li>5. Implementation of Sepsis 6</li> <li>6. Correct diagnosis</li> </ol>
<b>Epilepsy (n=4)</b> 2015 (n=2), 2019/2020 (n=2)	<ol style="list-style-type: none"> <li>1. ABCDE assessment of pregnant woman</li> <li>2. Recognise seizure</li> <li>3. Assess differential diagnoses</li> <li>4. Appropriate management of seizure</li> <li>5. Escalation of care/ request senior help</li> </ol>
<b>Symptomatic ventricular tachycardia (n=2)</b> 2015 (n=0), 2019/2020 (n=2)	<ol style="list-style-type: none"> <li>1. ABCDE assessment of pregnant woman</li> <li>2. Recognition of Ventricular Tachycardia</li> <li>3. Recognition of adverse clinical features</li> <li>4. Escalation/Call for help/Crash call</li> <li>5. Provide supportive care (eg, fluids)</li> <li>6. Correct treatment decision</li> </ol>
<b>Asthma (n=3)</b> 2015 (n=3), 2019/2020 (n=0)	<ol style="list-style-type: none"> <li>1. ABCDE assessment of pregnant woman</li> <li>2. Recognition of asthma</li> <li>3. Implementation of BTS Asthma Guidelines</li> <li>4. Recognise severity and trigger for critical care referral</li> <li>5. Escalation to senior team</li> </ol>
<b>Pulmonary oedema (n=3)</b> 2015 (n=1), 2019/2020 (n=2)	<ol style="list-style-type: none"> <li>1. ABCDE Assessment of pregnant woman</li> <li>2. Recognition of heart failure</li> <li>3. Recognition and management of acute pulmonary oedema</li> <li>4. Recognise severity and trigger for critical care referral.</li> <li>5. Escalation to senior team</li> <li>6. Deliver appropriate advanced life support</li> </ol>

...BTS, British Thoracic Society.

simulated performance.<sup>20 21</sup> Observational analysis of leadership behaviours of surgical teams during actual operations revealed that, during more complex phases of an operation, having one central clear leader rather than shared leadership resulted in better attainment of team goals.<sup>22</sup>

This study is to our knowledge the first to conduct a detailed analysis of teamwork behaviour over time, during simulated medical deterioration due to medical conditions in pregnant women. Simulated practice is a promising avenue for research, which has been under used to date.<sup>23</sup> The study had two aims: first, to explore the relationship between teamwork behaviours that occur at different timepoints during an episode of clinical care, and second, to explore the relationship between teamwork and simulated clinical performance.

## METHOD

### Sample

The corpus consisted of 17 audio visually recorded simulated scenarios recorded as part of the Multi-Disciplinary Simulation Training for Medical Emergencies in Obstetrics (MEMO) course.<sup>23</sup> Recordings were randomly selected from a set of standardised MEMO courses delivered at a large simulation training centre in London, UK (May to July 2015 (n=9 scenarios) and December 2019 to January 2020 (n=8 scenarios)). Five different scenarios were recorded based on MBRRACE report cases,<sup>10</sup> or real incidents within the institution. Scenario topics are listed in table 1. In each scenario, a pregnant woman with deteriorating health due to a medical condition not related to her pregnancy

(eg, epilepsy) is cared for by an interprofessional team in an acute (hospital) setting. Scenarios mean duration was 622.67s (SD: 186.76; range: 287.40–1060.59). Each scenario involved a high fidelity Maternal Simulator (Noelle<sup>24</sup>), which is a sophisticated full-size female manikin, and an embedded simulation practitioner was also present playing the role of a student midwife providing prompts if the scenario stalled.

Recordings included 62 qualified healthcare professionals working in the UK National Health Service (midwives (n=18), obstetricians (n=24) medical physicians—doctors that are not obstetricians but from other medical specialities (n=20)). Each scenario involved a minimum of 3, or a maximum of 4, unique participants, most of whom had not worked together previously; This is similar to clinical practice, where team members often do not know each other.

At the start of each training day, participants were provided with a study information sheet, given an opportunity to provide their written consent to participate and offered their right to withdraw. Participants were informed that their participation during the day would be audio visually recorded for subsequent video analysis. Participants were instructed to respond to events in the simulation as they would during routine clinical care. Participants were briefed on the simulator and environment, and were debriefed after each scenario using a structured debriefing approach<sup>25</sup> by two trained and experienced debriefers. They participated in one scenario during the day and observed for the rest of the time. MEMO course details are presented elsewhere.<sup>23</sup>

The same interprofessional team of clinicians involving obstetricians, medical physicians and midwives designed the course and delivered the course on all occasions. This team was led by one of the coauthors, AB. The course was highly protocolised to ensure both the scenarios and the standard of course delivery remained consistent. The course manual included detailed scenario content, the role of the embedded practitioner (EP) and predefined essential clinical actions that trainees were expected to complete during each scenario.

### Analysis of teamwork behaviours

Teamwork behaviours displayed by scenario participants were identified through microanalysis of behaviour. Observations used the Temporal Observational Analysis of Teamwork (TOAsT) framework. This is presented in figure 1<sup>26</sup> and is an observational framework consisting of five overarching *teamwork domains* (eg, *Leading the team*). These teamwork domains are operationalised through 23 *observable behaviours*, which are the specific verbal and non-verbal behaviours that can be identified during observations of teams (eg, setting a task for the team to complete). Observable behaviours are then grouped conceptually based on the function they have within the interaction. For example, the observable behaviour of ‘task setting’ would fall into the behavioural functional category of ‘planning’. The observable behaviours are grouped into 13 *behavioural functions* (figure 1). TOAsT is a framework for identifying observable behaviours. Although attitudes are not directly observable, the expression of attitudes in behaviour to team members is observable. For example, negative attitudes are inferred from behaviours such as ignoring team members when they occur in the context of a difficult team interaction. Although it is possible that ignoring others might be due to factors such as task fixation, the inference of negative attitudes was only made if the quality of the interaction was inhibited or conflicted. Although precision in such inferences is difficult to establish, a structured observational tool, review by research team members, and multiple

Teamwork Domain	Functions (13)	Observable Behaviours (23)
Leading the Team	Delegating	Instruction Workload redistribution
	Information Gathering	Requesting information
	Planning	Task setting Goal Setting
	Disseminating Rationale	Coordinating information Big Picture Task rationale
Developing a Shared Mental Model	Clarifying information	Evaluating others' contributions Providing information upon request Information reflection
	Information sharing	Talking to the room (action/information)
Assistance	Providing Assistance	Helping others with their tasks Completing others' tasks for them
	Requesting assistance	Asking others for help
Monitoring Team Performance	Explicit	Speaking up to explicitly challenge others performance
	Implicit	Subtle challenge of others' performance Nonverbal performance monitoring
Team Attitudes	Positive	Valuing others' contributions Positive feedback/comments
	Negative	Ignoring others' contributions
	Disagreement	Task based Process based

Figure 1 Temporal Observational Analysis of Teamwork (TOAsT) framework.

trained raters were employed to increase the reliability of coding across scenarios.

Using the TOAsT framework allows observable behaviours (n=23) to be coded from video, these can then be categorised based on their ‘behavioural function’ (n=13) and these can then be further classified into the teamwork domain that they belong to (n=5; figure 1).

Two trained TOAsT raters (a psychologist, ML, and a research student under supervision of ML) coded TOAsT *observable behaviours* in the linguistic annotation software ELAN.<sup>27</sup> ELAN allows raters to apply codes directly to video, providing a behavioural time series frame by frame. To allocate codes, raters viewed each scenario multiple times, rewinding and reviewing small sections of video footage. Observable behaviours of all participants in each scenario were coded. Two annotators achieved 85% agreement in behaviours identified (Cohen’s Kappa=0.79, SE=0.03). Differences in identified behaviours between raters were reconciled. There were no differences between raters in event durations. The resulting detailed behavioural time series was exported into the statistical software package SPSS<sup>28</sup> for statistical analysis.

### Clinical performance in simulated practice

The MeMO course is highly protocolised and follows a course manual. Each scenario is described in detail within the manual with predefined essential clinical actions that trainees were expected to complete. For scenario topics, and the essential clinical actions associated with it, see table 1. Two clinicians, who were involved in development and delivery of the course (one obstetrician and one medical physician from outside obstetrics), watched each scenario independently and decided whether each clinical action was performed spontaneously by participants (ie, unassisted by EP). Actions performed spontaneously were coded as one, while actions not performed, or performed only after assistance by the EP, were coded as zero. Clinical raters reached 100% agreement on all scenarios. For each scenario, the number of actions spontaneously performed was calculated as a percentage of the total number of possible actions (eg, three actions spontaneously performed out of a possible five gave a score of 60%). This percentage was used as an index of simulated clinical performance, with a higher percentage indicating better performance.

## Statistical analyses

Statistical analyses were conducted using SPSS V.24.<sup>28</sup> The behavioural time series of each scenario was aggregated into 30 s windows, to facilitate analysis of temporal dynamics.<sup>19</sup> This time unit was chosen as no behaviour lasted longer than 30 s. The frequency and total duration of behaviours (in seconds) displayed by each participant within each 30 s window were identified. Behaviours crossing 30 s boundaries were counted in both adjacent windows, with the precise duration (in seconds) within each window recorded.

To enable analysis of sections of interaction, while adjusting for the variations in scenario duration, each scenario was divided into three sections of equal duration based on overall scenario duration. This is an accepted approach for standardising recordings of naturalistic behaviour for analysis.<sup>19 29</sup> The time divisions were calculated as follows: (total scenario duration (in seconds)/3 = duration of each time section (in seconds)); scenario start (T1), middle (T2) and end (T3). The mean duration of each time section across all 17 scenarios was 190 s (SD=62.18; range: 60–330 s).

Spearman's correlations explored the relationship between behaviours designed to *lead the team* and *develop a shared mental model* over time. Correlations between behaviours at T1 and T2, and between behaviours at T2 and T3 were investigated.

The relationship between teamwork behaviours and simulated clinical performance was explored using generalised estimating equations (GEE). This was limited to the teamwork behaviours for which there was sufficient data to enable statistical analysis. GEE was selected as it provides the parameters of a general linear model for data that are clustered. For example, these data are clustered by scenario, meaning that we would expect correlations between behaviours that occur within the same scenario, because they involve the same people and may be related to each other. GEE adjusts for intrascenario correlations, and accounts for the fact that data are organised sequentially.

In order to identify which teamwork behaviours were associated with simulated clinical performance overall, a GEE explored the relationship between simulated clinical performance (dependent variable: % actions correct) and teamwork behaviours (predictor variables: *leading the team* and *developing the shared mental model* behaviours) aggregated across all professional groups and time points. Behaviours significantly associated with simulated clinical performance were further analysed using GEE models to identify behavioural predictors of simulated clinical performance (DV) as they are displayed by each professional group at each of the three time points. Significance levels were set at  $p < 0.05$ . Effect sizes were calculated as  $\Phi = \sqrt{\chi^2/n}$ .

## RESULTS

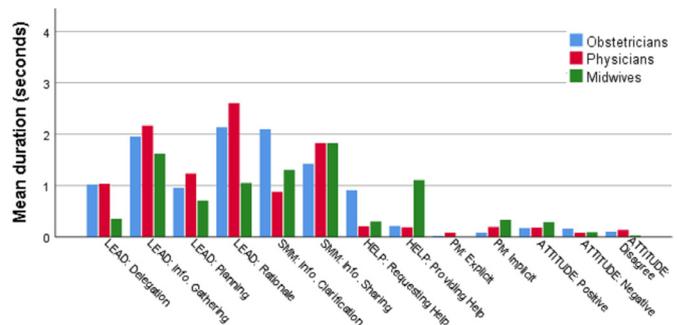
### Simulated clinical performance

Performance scores ranged from 0% to 100% with a median of 80% (mean 71% SD=27).

### Overview of behavioural durations

Across the sample of 17 scenarios, 3639 distinct behaviours were observed, with a mean duration of 2.6 s (SD=2.7, range: .02–30 s). Behavioural frequencies and durations were highly correlated for all behaviours ( $Rho \geq 0.9$ ), and so the mean duration of behaviour was used for all subsequent analyses.

The mean durations of behavioural functions (see TOAsT—functions column, figure 1) (per 30 s interval) by professional group (obstetricians, medical physicians and midwives) are displayed in figure 2. Participants spent most time displaying



**Figure 2** Mean duration of teamwork behaviours displayed per 30 s by professional group. The teamwork domain that each behaviour belongs to is indicated in the graph, that is, LEAD—*leading the team*, SMM—*developing a shared mental model*, HELP—*requesting and providing assistance*, PM—*performance monitoring*.

behaviours in the teamwork domains of *leading the team* (delegating, planning, disseminating rationale and information gathering), and *developing the shared mental model* (information clarification and information sharing). Comparatively less time was spent displaying behaviours in the domains of *assisting* (requesting and providing help), *monitoring the team* (implicit and explicit performance monitoring) and *team attitudes* (positive attitudes, negative attitudes and disagreement), which precluded further statistical analysis. A descriptive analysis of the behaviours that were used less will be presented below. The remainder of the results section will focus on behaviours in the domains of *leading the team* and *sharing the mental model*.

### Descriptive analysis of teamwork behaviours excluded from the statistical analyses

Obstetricians displayed most help requests, while midwives provided the most help. All professional groups spent very little time displaying *explicit performance monitoring behaviours* and midwives did not display it at all. However, midwives spent comparatively more time than other professional groups, displaying *implicit performance monitoring* (ie, implicit communication designed to get others to identify their own mistakes/errors). The use of *positive attitude* (eg, providing positive encouragement to team members) and *negative attitude* behaviours (eg, ignoring others) did not appear to differ across professional groups. Midwives rarely displayed disagreement.

### Temporal dynamics of teamwork behaviours across all participants

Correlations between behaviours designed to *lead the team* (*delegation*, *information gathering*, *planning*, and *disseminating rationale*) and *develop a shared mental model* (*information clarification* and *information sharing*) across all participants are displayed in table 2. More *delegation* at T1 (start) was associated with less *information sharing* at T2 (middle) ( $p < 0.01$ ). More *planning* and *disseminating rationale* at T1 were associated with more *dissemination of rationale* at T2 ( $p < 0.05$ ). *Information clarification* at T1 was associated with more *information clarification* at T2 ( $p < 0.05$ ).

More *delegation* at T2 was significantly associated with more *information clarification* at T3 (end) ( $p < 0.01$ ), while more *planning* at T2 was significantly associated with less *delegation* at T3 ( $p < 0.05$ ). More *dissemination of rationale* at T3 was significantly associated with more *dissemination of rationale* ( $p < 0.01$ ), less *information clarification* ( $p < 0.01$ ) and more *information*

**Table 2** Spearman's correlations of the mean duration of teamwork behaviours displayed across all participants at the start (T1) middle (T2) and end (T3) of the scenario

	Behaviours Time 2 (middle)					
	Delegation	Info. gathering	Planning	Rationale	Info. Clarification	Info. Sharing
Behaviours Time 1 (start)						
Delegation	0.005	-0.397	-0.157	-0.419	0.194	-0.571*
Info. gathering	0.047	-0.252	0.002	0.277	-0.333	-0.056
Planning	-0.402	0.093	0.319	0.507*	-0.118	0.127
Rationale	-0.373	-0.213	0.377	0.566*	-0.377	0.275
Info. clarification	0.262	0.169	-0.375	-0.211	0.600*	-0.279
Info. sharing	-0.042	0.123	0.127	0.250	-0.289	0.213
Behaviours Time 3 (end)						
Delegation	0.226	0.399	-0.484*	0.038	0.426	-0.140
Info. gathering	-0.275	0.282	0.010	0.613**	-0.458	0.257
Planning	-0.300	0.226	0.104	0.373	-0.325	0.228
Rationale	-0.264	0.278	0.042	0.683**	-0.655**	0.574*
Info. clarification	0.642**	0.127	0.270	-0.368	0.184	0.262
Info. sharing	-0.343	0.088	-0.203	0.385	-0.120	-0.020

\*\*p<0.01. \*p<0.05.

sharing at T2 (p<0.05). More dissemination of rationale at T2 was also associated with more information gathering at T3 (p<0.01).

### Relationship between teamwork and simulated clinical performance

Table 3 shows the results of the GEEs analysing differences in the duration of leadership and shared mental model behaviours between scenarios with good and poor simulated clinical performance (% correct actions) across all professional groups and all time points. Overall, better simulated clinical performance was significantly associated with less delegation, more information gathering, dissemination of rationale and information sharing (see table 3). As such, these teamwork behaviours were included in the subsequent GEE analysis exploring the relationship between simulated clinical performance and teamwork behaviours of each professional group at each time point (T1-3) (see table 4).

Significant results are reported in table 4. At the start of scenarios (T1) with better simulated clinical performance, obstetricians display less delegation (p<0.01, Phi=0.24) and spend more time gathering information (p<0.01, Phi=0.26) and sharing information with the team (p<0.01, Phi=0.28), while midwives gather information (p<0.01, Phi=0.35) and disseminate rationale (p<0.01, Phi=0.39). No significant relationships between teamwork and simulated clinical performance were identified at T2. At the end of scenarios (T3) with better simulated clinical performance, dissemination of rationale is displayed

by both medical physicians (p=0.03, Phi=0.20), and midwives (p=0.02, Phi=0.22), while medical physicians also display more information sharing (p=0.04, Phi=0.20). Effect sizes ranged from 0.20 to 0.39, indicating small-to-medium effects, with the largest effect sizes for midwives' information gathering and rationale at T1.

### DISCUSSION

The findings of this study demonstrate the importance of teamwork for good clinical performance in simulated scenarios requiring management of medical deterioration due to new or pre-existing medical conditions in pregnant women. It provides clear evidence of which teamwork behaviours may be associated with better performance in simulated practice, and therefore which behaviours to potentially target in future research. Better simulated performance was predicted by teamwork behaviour in the opening and closing moments of a clinical patient care event. Specifically, scenarios with better simulated clinical performance were characterised by shared leadership between obstetricians and midwives at the start of the interaction, with obstetricians delegating less, midwives disseminating more rationale and both engaging in more information gathering behaviour. Towards the end of the interaction, better simulated clinical performance was associated with medical physicians and midwives disseminating their rationale to the team. Exploring the temporal dynamics of teamwork, we found that delegation at the start of a scenario is associated with team members not sharing information and

**Table 3** Overall teamwork predictors of simulated clinical performance across all professional groups and time points.

Behaviour	Exp (B)	SE	95% CI		Wald $\chi^2$	P value
			Lower	Upper		
Delegation	-0.005	0.0026	-0.010	0.000	3.996	0.046
Information gathering	0.003	0.0011	0.000	0.005	5.398	0.020
Planning	0.001	0.0020	-0.003	0.005	0.287	0.592
Rationale	0.003	0.0012	0.001	0.006	7.501	0.006
Information clarification	-0.002	0.0010	-0.004	0.000	2.997	0.083
Information sharing	0.001	0.0006	0.000	0.002	5.602	0.018

Model QIC = 89.84.

Table 4 Teamwork predictors of simulated clinical performance by professional group and time point

Time	Professional group	Behaviour	Exp (B)	SE	95% CI		Wald $\chi^2$	P value	Phi
					Lower	Upper			
T1—start QIC: 18.2	Obstetricians	Delegation	-0.001	0.0005	-0.002	0.000	6.855	<0.01	0.24
		Information gathering	0.001	0.0005	0.000	0.002	7.917	<0.01	0.26
		Information sharing	0.001	0.0002	0.000	0.001	9.932	<0.01	0.28
	Midwives	Information gathering	0.002	0.0005	0.001	0.003	13.829	0.002	0.35
		Rationale	0.002	0.0005	0.001	0.003	17.591	<0.001	0.39
T3—end QIC: 20.1	Medical physicians	Rationale	0.006	0.0029	0.001	0.012	4.608	0.03	0.20
		Information sharing	0.006	0.0028	0.000	0.011	4.377	0.04	0.20
	Midwives	Rationale	0.006	0.0023	0.001	0.010	5.534	0.02	0.22

rationale later in the scenario. However, when behaviours designed to develop a shared mental model (information sharing, information clarification) and to share leadership thinking (rationale and planning) were used at the start of the scenario, they were associated with continued use as the scenario progressed.

The opening moments of scenarios with poorer simulated clinical performance were characterised by obstetricians spending less time gathering or sharing information with their team and more time delegating to others. This fits with the literature showing that emergency teams that act ‘*too fast*’ may fail to make an initial assessment of the situation and decision making may suffer as a result, leading to poorer clinical performance.<sup>30</sup> Although a speed accuracy trade-off is one explanation for this pattern, there are several other possible explanations. One hypothesis is that early delegation by the doctor in the scenario may define a hierarchical dynamic from the start of the interaction, disempowering other team members (eg, midwives) from performing at the peak of their professional ability in the context of the team. Our findings demonstrating a relationship between delegation at the start of the scenario and less spontaneous sharing of information and rationale later in the scenario, further support this theory. An alternative explanation is that teams with poorer simulated clinical performance, may have less experienced, or less capable, team members who require more explicit delegation and instruction. An experienced team leader may recognise this early and engage in more delegation. Thus, the relationship between poorer performance and early delegation may be indicative of the lower baseline performance of these teams.

The pattern of early delegation may be problematic for several reasons. First, it could mean that the person delegating does so without having assimilated the knowledge they need to make accurate decisions (eg, acting too fast<sup>30</sup>). Second, team members are physically or cognitively engaged in tasks they have been delegated at the start of the interaction, and therefore may not attend to clinically relevant discussions that occur during this time. This may hamper the teams’ ability to develop a shared understanding of the clinical picture. This, in turn, may result in staff being less able to use their own initiative to begin necessary subsequent follow-up tasks. However, if the team members are less capable or experienced, early delegation by an experienced leader may be necessary.

In line with previous studies that have examined the relationship between teamwork and clinical performance in managing emergencies in the context of pregnancy, this study highlights the critical roles of shared leadership<sup>31</sup> and building a shared mental model<sup>17 18</sup> in facilitating good outcomes. This is one of the first empirical studies to identify a link between the temporal dynamics of team communication and simulated clinical

performance. The findings are supported by research in surgical teams, which found that shared leadership was effective during certain phases of surgery and not beneficial at other times.<sup>22</sup> In this study, the type of leadership behaviour in the opening minutes of the scenario was critical to the subsequent teamwork, and to the effective performance of that team. Although effect sizes were small to medium, they are in line with those expected in a study of this nature.<sup>32</sup> In making this link, we demonstrate the value of sequential, temporal analysis of teamwork behaviour for revealing interpersonal dynamics that may be masked by exploring the interaction as a whole, or by focusing on only one team member.

Consistent with calls to broaden the scope of simulation research,<sup>33 34</sup> this work also shows how simulation can be used to study team dynamics and individual behaviour in ways that are much more difficult to do in clinical environments dedicated to patient care.<sup>35</sup> By designing scenarios that provide opportunities for leadership within interprofessional teams, and for team members to practice leadership behaviours that are associated with positive team performance, these results can contribute knowledge to the simulation setting from which the research emerged and help simulation educators to design opportunities for positively reinforcing practice.<sup>36</sup> Furthermore, an awareness of the potential for some leadership behaviours to be more beneficial at certain points of a clinical care situation than others, can be a valuable discussion point in debrief conversations.

### Strengths and limitations

This study had several strengths. First, all behaviour of all the participants was meticulously examined and coded frame by frame to uncover both the overt and nuanced teamwork behaviours and their patterns over time. Second, an index of simulated clinical performance was developed based on the scenario aims. Thirdly, sophisticated statistical methods (ie, GEEs) were employed to adjust for intrascenario correlations and accommodate time series data.

A limitation of this study was the use of video-recorded simulated clinical interactions. Although we do not know how the teamwork behaviour patterns identified in the current study equate to real-world behaviour, the scenarios were based on real-world incidents and were developed by a team of experienced clinicians from different professional backgrounds. A second limitation was that the data we gathered were not collected specifically for the purpose of teamwork analysis; this is a limitation shared by other studies examining human behaviour in naturalistic settings. A third limitation was sample size, due to the time and labour-intensive nature of the analysis. However, the data produced by the analysis are rich, resulting in a dataset

of over 3600 behaviours. Finally, we were not able to control for the order of the analysed scenarios in the training day and this may have affected the findings.

Future research should focus on those teamwork behaviours that this research and the broader literature have highlighted as critical for clinical performance. There is also scope to further explore the methodological challenges of analysing episodes of clinical care. For example, the choice of time segments to compare is potentially important. Dividing scenarios into equal time periods, as in this study, is one approach, but there may be merit in determining whether there are natural transition points which delineate task phases. This is not feasible for all clinical interactions, including the ones used in this study in which there were no transition points. In other settings, however, this may be possible and would provide a nuanced understanding of how task demands are related to teamwork behaviour.

## CONCLUSION

In line with recent reports and research,<sup>10 11 13 14 17 18</sup> this study confirms the central role of teamwork in simulated clinical performance, but suggests that the opening moments of a patient care encounter may be important for establishing effective teamwork and performance. Shared leadership, and development of the shared mental model at the very start of the interaction are associated with better simulated performance, suggesting these behaviours are associated with teams working together effectively. This study develops our understanding of the behaviours that are potentially effective for interdisciplinary teamwork and the relationship of teamwork to simulated performance in these complex clinical scenarios, and provides evidence to inform clinical education of interprofessional teams.<sup>24 37</sup>

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## REFERENCES

- Weller J, Boyd M, Cumin D. Teams, tribes and patient safety: overcoming barriers to effective teamwork in healthcare. *Postgrad Med J* 2014;90:149–54.
- Schmutz JB, Meier LL, Manser T. How effective is teamwork really? the relationship between teamwork and performance in healthcare teams: a systematic review and meta-analysis. *BMJ Open* 2019;9:e028280.
- Weller JM, Barrow M, Gasquoin S. Interprofessional collaboration among junior doctors and nurses in the hospital setting. *Med Educ* 2011;45:478–87.
- Hall P. Interprofessional teamwork: professional cultures as barriers. *J Interprof Care* 2005;19 Suppl 1:188–96.
- Liberati EG, Gorli M, Scaratti G. Invisible walls within multidisciplinary teams: disciplinary boundaries and their effects on integrated care. *Soc Sci Med* 2016;150:31–9.
- Manser T. Teamwork and patient safety in dynamic domains of healthcare: a review of the literature. *Acta Anaesthesiol Scand* 2009;53:143–51.
- Manser T, Harrison TK, Gaba DM, et al. Coordination patterns related to high clinical performance in a simulated anesthetic crisis. *Anesth Analg* 2009;108:1606–15.
- Sutcliffe KM, Lewton E, Rosenthal MM. Communication failures: an insidious contributor to medical mishaps. *Acad Med* 2004;79:186–94.
- Reader TW, Flin R, Cuthbertson BH. Communication skills and error in the intensive care unit. *Curr Opin Crit Care* 2007;13:732–6.
- Knight M, Kenyon S, Brocklehurst P. *Improving Mothers' Care—Lessons Learned to Inform Future Maternity Care From the UK and Ireland Confidential Enquiries Into Maternal Deaths and Morbidity 2009-12*. Oxford, England: National Perinatal Epidemiology Unit, University of Oxford, 2014.
- Manktelow B, Smith L, Seaton S. *MBRRACE-UK perinatal mortality surveillance report, UK perinatal deaths for births from January to December 2014*. Leicester: The Infant Mortality and Morbidity Studies, Department of Health Sciences, University of Leicester, 2016.
- Knight M. The findings of the MBRRACE-UK Confidential enquiry into maternal deaths and morbidity. *Obstet Gynaecol Reprod Med* 2019;29:21–3.
- Gynaecologists RCoOa. *Each baby counts 2015 full report*, 2017.
- Kirkup B. *The report of the Morecambe Bay investigation*. London: The Stationery Office, 2015.
- Cornthwaite K, Edwards S, Siassakos D. Reducing risk in maternity by optimising teamwork and leadership: an evidence-based approach to save mothers and babies. *Best Pract Res Clin Obstet Gynaecol* 2013;27:571–81.
- Salas E, Sims DE, Burke CS. Is there a "Big Five" in Teamwork? *Small Group Res* 2005;36:555–99.
- Brogaard L, Kierkegaard O, Hvidman L, et al. The importance of non-technical performance for teams managing postpartum haemorrhage: video review of 99 obstetric teams. *BJOG* 2019;126:1015–23.
- Siassakos D, Bristowe K, Draycott TJ, et al. Clinical efficiency in a simulated emergency and relationship to team behaviours: a multisite cross-sectional study. *BJOG* 2011;118:596–607.
- Lehmann-Willenbrock N, Allen JA. Modeling temporal interaction dynamics in organizational settings. *J Bus Psychol* 2018;33:325–44.
- Kolbe M, Burtscher MJ, Wacker J, et al. Speaking up is related to better team performance in simulated anesthesia inductions: an observational study. *Anesth Analg* 2012;115:1099–108.
- Burtscher MJ, Kolbe M, Wacker J, et al. Interactions of team mental models and monitoring behaviors predict team performance in simulated anesthesia inductions. *J Exp Psychol Appl* 2011;17:257–69.
- Pasarakonda S, Grote G, Schmutz JB. A strategic core role perspective on team coordination: benefits of centralized leadership for managing task complexity in the operating room. *Human Factors* 2020;0018720820906041.
- Lavelle M, Abthorpe J, Simpson T, et al. MBRRACE in simulation: an evaluation of a multi-disciplinary simulation training for medical emergencies in obstetrics (MEMO). *J Obstet Gynaecol* 2018;38:781–8.
- Gaumard. Gaumard scientific CO. I. Available: <https://www.gaumard.com/catalogsearch/result/?q=noelle+materal+simulator> [Accessed 25 May 2017].
- Jaye P, Thomas L, Reedy G. 'The diamond': a structure for simulation debrief. *Clin Teach* 2015;12:171–5.
- Lavelle M, Reedy GB, Cross S, et al. An evidence based framework for the temporal observational analysis of teamwork in healthcare settings. *Appl Ergon* 2020;82:102915.
- Annotation by category – ELAN and ISO DCR. *The 6th International Conference on language resources and evaluation*. Marrakech, Morocco, 2008.
- IBM Corporation. *IBM SPSS Statistics for Windows, Version 22.0*. [program. Armonk, New York, 2013.
- Lavelle M, Healey PGT, McCabe R. Participation during first social encounters in schizophrenia. *PLoS One* 2014;9:e77506.
- Rall M, Glavin R, Flin R. The '10-seconds-for-10-minutes principle'. *Bull R Coll Anaesth* 2008;51:2614–6.
- Janssens S, Simon R, Barwick S, et al. Leadership sharing in maternity emergency teams: a retrospective cohort study in simulation. *Bmj Stel* 2020;6:135–9.

- 32 Schäfer T, Schwarz MA. The meaningfulness of effect sizes in psychological research: differences between sub-disciplines and the impact of potential biases. *Front Psychol* 2019;10:813.
- 33 Gaba DM. The future vision of simulation in healthcare. *Simul Healthc* 2007;2:126–35.
- 34 LeBlanc VR, Manser T, Weinger MB, *et al*. The study of factors affecting human and systems performance in healthcare using simulation. *Simul Healthc* 2011;6 Suppl:S24–9.
- 35 Lamé G, Dixon-Woods M. Using clinical simulation to study how to improve quality and safety in healthcare. *BMJ Simul Technol Enhanc Learn* 2020;6:87–94.
- 36 Dieckmann P, Patterson M, Lahlou S, *et al*. Variation and adaptation: learning from success in patient safety-oriented simulation training. *Adv Simul* 2017;2:21.
- 37 Kumar A, Sturrock S, Wallace EM, *et al*. Evaluation of learning from practical obstetric Multi-Professional training and its impact on patient outcomes in Australia using Kirkpatrick's framework: a mixed methods study. *BMJ Open* 2018;8:e017451.