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How effective is teamwork really? The relationship between teamwork and performance in healthcare teams: A systematic review and meta-analysis

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How effective is teamwork really? The relationship between teamwork and performance in healthcare teams: A systematic review and meta-analysis

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ABSTRACT

Objectives To investigate the relationship between teamwork and clinical performance and potential moderating variables of this relationship.

Design Systematic review and meta-analysis.

Methods Data sources were searched up to June 2018 and included PubMed, manual backward search of relevant reviews, manual backward and forward search of studies included in the meta-analysis and contacting of selected authors via e-mail. Studies were included if they reported a relationship between a teamwork process and a performance measure. Moderator variables (i.e. professional composition, team familiarity, average teams size, task type, patient realism and type of performance measure) were coded and random-effect models were estimated. Two investigator independently extracted information on study characteristics in accordance with PRISMA guidelines.

Results The review identified 2002 articles of which 31 were included in the meta-analysis comprising 1390 teams. The sample-sized weighted mean correlation was r = .28, indicating that teamwork is positively related to performance. The test of moderators was not significant, suggesting that the examined factors did not influence the average effect of teamwork on performance.

Conclusion Teamwork has a medium-sized effect on performance. The analysis of moderators illustrated that teamwork relates to performance regardless of characteristics of the team or task. Therefore, healthcare organizations should recognize the value of teamwork and emphasize approaches that maintain and improve teamwork for the benefit of their patients.

ARTICLE SUMMARY

Strengths and limitations of this study

- This systematic review evaluates available studies investigating the effectiveness of teamwork processes.
- 31 studies have been included resulting in a substantial sample size of 1390 teams.
- The sample size of the primary studies included is usually low.
- For some subgroup analysis, the number of studies included was small.

INTRODUCTION

Teams are ubiquitous in healthcare and must work across professional, disciplinary and sectorial boundaries. Experts agree that effective teamwork anchors safe and effective care at various levels of the healthcare systems[1-4] leading to a relatively recent shift towards team research and training.[5-7] Our field now widely accepts that a team of individual experts does not necessarily make an expert team.[8,9]

However, the literature investigating healthcare teams reports mixed and sometimes even contradicting results about the relationship between teamwork and clinical performance.[9] Some studies find a large effect of teamwork on performance (e.g. Carlson et al.[10]) while others report small or no relationships.[11,12] This inconsistency arises due to several reasons. First, the conceptual and empirical literature examining teamwork is fragmented and research examining teamwork effectiveness is spread across disciplines including medicine, psychology and organization science. Therefore, researchers and practitioners often lack a common conceptual foundation for investigating teams and teamwork in healthcare. Second, research studies on teamwork in healthcare usually exhibit small sample sizes because of the challenges of recruiting actual professional teams and carefully balancing research with patient care priorities. Small sample sizes, however, increase the likelihood of reporting results that fail to represent true effect. Third, studies investigating healthcare teams often ignore important context variables of teams (e.g. team composition and size, task characteristics, team environment) that likely influence the effect that teamwork has on clinical performance.[13,14]

These inconsistencies in the teamwork literature may lead to confusion about the importance of teamwork in healthcare, thus giving voice to critics who hinder efforts to improve teamwork. We aim to address these problems with a meta-analytical study investigating the performance implications of teamwork. A meta-analytical approach moves beyond existing reviews on teamwork in healthcare[9,15-18] and quantitatively tests if the widely advocated positive effect of teamwork on performance holds true. In addition, this approach allows us to investigate context variables as moderators that may influence the effect of teamwork on performance, meaning that this effect might be stronger or weaker under certain conditions. Previous meta-analyses[19,20] focused mainly on the effectiveness of team trainings but not on the effect of teamwork itself. This meta-analysis will generate strong quantitative evidence to inform the relevance of future interventions targeting teamwork in healthcare organizations.

In the following we will first establish an operational definition of teamwork, elaborate on relevant contextual factors, and present our respective meta-analytic results and their interpretation.

Teamwork and performance

Teamwork as a term is widely used and often difficult to grasp. However, we absolutely require a clear definition of teamwork especially for team trainings that target specific behaviors. *Teamwork* is a process that describes interactions among team members who combine collective resources to resolve task demands (e.g. giving clear orders).[21,22] Teamwork or team processes can be differentiated from *taskwork*. *Taskwork* denotes a team's individual interaction with tasks, tools, machines and systems.[22] *Taskwork* is independent of other team members and is often described as *what* a team is doing whereas *teamwork* is *how* the members of a team are doing something with each other.[23] Therefore, *team performance* represents the accumulation of teamwork and taskwork (i.e. what the team actually does).[17]

Team performance is often described in terms of inputs, processes and outputs (IPO).[21,24-26] *Outputs* like quality of care, errors or performance are influenced by team related *processes* (i.e. teamwork) like communication, coordination or decision making. Furthermore, these processes are influenced by various *inputs* like team members experience, task complexity, time pressure and more. This IPO framework helps to systematize the mechanisms that predict team performance and represents the basis for the selection of the teamwork studies included in our meta-analysis.

Contextual factors of teamwork effectiveness

Based on a large body of team research from various domains, we hypothesize that several contextual and methodological factors might moderate the effectiveness of teamwork, indicating that teamwork is more important under certain conditions.[27,28] Therefore, we investigate several factors: (a) team characteristics (i.e. professional composition, team familiarity, team size); (b) task type (i.e. routine vs. non-routine tasks); (c) two methodological factors related to patient realism (i.e. simulated vs. real) and the type of performance measures used (i.e. process vs. outcome performance). In the following we discuss these potentially moderating factors and the proposed effects on teamwork.

Professional composition. We distinguished between interprofessional and uniprofessional teams. Interprofessional teams consist of members from various professions that must work together in a coordinated fashion.[29] Diverse educational paths in interprofessional teams may shape respective values, beliefs, attitudes and behaviors.[30] As a result team members with different backgrounds might perceive and interpret the environment differently and have a different understanding of how to work together. Therefore, we assume that explicit teamwork is especially important in interprofessional teams compared to uniprofessional teams.

Team familiarity. If team members have worked together, they are familiar with their individual working styles; and roles and responsibilities are usually clear. If a team works together for the first time, this potential lack of familiarity and clarity might make teamwork even more important. Therefore, we differentiate between *real teams* that also work together in their everyday clinical practice and *experiential teams* that only came together for study purposes.

Team size. Another factor that may moderate the relationship between teamwork and performance is team size. Since larger teams exhibit more linkages among members than smaller teams, they also face greater coordination challenges. Also, with increasing size teams have greater difficulty developing and maintaining role structures and responsibilities. For these reasons, we expect the influence of teamwork on clinical performance to be stronger in larger teams as compared to smaller teams.

Task type. Routine situations are characterized by repetitive and unvarying actions (e.g. standard anaesthesia induction).[31] In contrast, non-routine situations exhibit more variation and uncertainty, requiring teams to be flexible and adaptive. Whereas team members mostly rely on pre-learned sequences during routine situations, during non-routine situations we assume that teamwork is more important in order for team members to resolve task demands.

Patient realism. Authors highlight the importance of using medical simulators in education.[32] Therefore, we investigate the realism used in a study (simulated vs. real patients) as a potential methodological factor that influences the relationship between teamwork and performance. Studies conducted with medical simulators might be more standardized and less influenced by confounding variables than studies conducted with real patients. Therefore, results from simulation studies might show stronger relationships between the two variables. Further, using simulated patients could cause individuals and teams to act differently than in real settings, thereby distorting the results. However, in the last decade high-fidelity simulators have become increasingly realistic, suggesting that the results from simulation studies generalize to real environments. Including realism as a contextual factor in our analysis will reveal if the effects of teamwork observed in simulation compare with real life settings. Better understanding would provide important insights about simulation use in teamwork studies.

Performance measures. As a second methodological factor, we expect that the type of performance measure used in a study influences the reported teamwork effectiveness. The literature usually differentiates between process- and outcome-related aspects of performance.[33,34] Process performance measures are action-related aspects and refer to adequate behaviour during procedures (e.g. adhering to guidelines), making them easier to assess. Outcome performance measures (e.g. infection rates after operations) follow team actions, with assessment occurring later than process measures. Outcome performance measures suffer from several factors: greater sensitivity to confounding variables (e.g. comorbidities), assessment challenges, and greater difficulty linking team processes to outcomes. Looking at the predictors of the survival of cardiac arrest patients illustrates the difference between the two types of performance measures. The main predictors for the survival (i.e. performance outcome) of a cardiac arrest patient are *"duration of the arrest"* and *"age of the patient less than 70"*.[35] Although a team delivers perfect basic life support (i.e. high process performance) the patient can still die (i.e. low outcome performance). Due to these methodological considerations, we expect that studies assessing process performance report a stronger relationship between teamwork and performance than studies assessing outcome performance.

METHODS

The study was conducted based on the recommendations of the PRISMA statement[36] as well as established guidelines in social sciences.[37,38] Through the combination of studies in the meta-analytical process, we will increase the statistical power and provide an accurate estimation of the true impact that teamwork has on performance.

Search strategy

We applied the following search strategy to select relevant papers: *a)* an electronic search of the data base PubMed (no limit was placed on date of publication, last search June 2018) using the key words *teamwork*, *coordination*, *decision making*, *leadership* and *communication* in combination with *patient safety*, *clinical performance*, the final syntax for PubMed is available online (Supplementary File), b) a manual backwards search for all references cited by 8 systematic literature reviews that focus on teamwork or non-technical skills in various healthcare domains ,[9,16,18,39-43] c) a manual backwards search for all references cited in studies we included in our meta-analysis, d) a manual forward search to identify studies that cite the studies we included in our meta-analysis, e) identification of relevant unpublished manuscripts via e-mail from authors currently investigating medical teams using specific mailing lists.

Inclusion criteria

Studies were included if a construct complied to the definition of teamwork processes outlined in the introduction (e.g. coordination, communication). In addition, studies needed to investigate the relationship between at least one teamwork process and a performance measure (e.g. patient outcome). When studies reported multiple estimates of the same relationship from the same sample (e.g. between coordination and more than one indicator of performance), those correlations were examined separately only as appropriate for sub-analyses, but an average correlation was computed for all global meta-analyses of those relationships to maintain independence.[44] All articles included in this meta-analysis are listed in Table 1 and Table 2.

For the criterion level of analysis, we included only effect sizes at the team level and not on an individual level. Therefore, the performance measure had to be clearly linked to a team. This approach aligns with research that strongly recommends against mixing levels of analysis in meta-analytic integrations.[45,46]

Two reviewers independently screened titles and abstracts from articles yielded in the search. Afterwards full texts of all relevant articles were obtained and screened by the same two reviewers. Agreement was above 90%. Any disagreement in the selection process was resolved through consensus discussion.

Data extraction

With the help of a jointly developed coding scheme, studies were independently coded by one of the authors (JS) and another rater, both with a background in industrial psychology and human factors. 20% of the studies were rated by both coders. Intercoder agreement was above 90%. Any disagreement was resolved through discussion. The data extracted comprised details of the authors and publication as well as important study characteristics and statistical relationships between a teamwork variable and performance (Table 2).

Coding of team characteristics

The *professional composition* of teams was coded either as "Interprofessional" if a team consisted of members from different professions (e.g. nurses and physicians) or as "Uniprofessional" if the members of the teams were of the same profession. *Team size* was coded as the number of members (average number if team size varied) of the investigated teams. Team familiarity was coded either as “experimental” or “real”. “Real” indicates that the team members also worked together in their everyday clinical practice. “Experimental” means that the teams only worked together during the study.

Coding of task characteristics

Task type was coded either as “Routine task” or “Non-routine task”. We defined “Non-routine tasks” as unexpected events that require flexible behavior often under time-pressure (e.g. emergency situations). “Routine tasks” describe previously planned standard procedures (e.g. standard anesthesia induction, planned surgery).

Coding of methodological factors

Patient realism was either coded as “Real patients” or “Simulated patients”. “Simulated patient” included a simulated or standardized patient whereas “Real patient” included real patients in clinical settings.

Clinical performance measures were coded either as “Outcome performance” or “Process performance”.[34,47] “Outcome performance” includes an outcome that is measured after the treatment process (e.g. infection rate, mortality). We focused only on patient-related outcomes and not on team outcomes (e.g. team satisfaction). “Process performance” describes the evaluation of the treatment process and describes how well the process was executed (e.g. adherence to guidelines through expert rating). Process performance measures are often based on official guidelines and extensive expert knowledge.[48] Thus, we assumed that process performance closely relates to patient outcomes.

Table 1. Descriptions of study objectives, settings and description of teamwork process and outcome measures

Authors	Year	Main study objectives	Participants and setting	Teamwork process measure	Outcome measure
Amacher, Schumacher, Legeret, et al.[64]	2017	To compare female and male rescuers in regard to cardiopulmonary resuscitation and leadership performance	Video observation of medical students managing cardiopulmonary resuscitation in a high-fidelity patient simulator	Structured observation of secure leadership statements within teams	Time until start chest compression Hands-on time within first 180 seconds
Brogaard, Kierkegaard, Hvidmand, et al.[65]	2018	To investigate the relationship between non-technical skills and clinical performance in obstetric teams	Video observation of obstetric teams (Obstetricians, obstetric nurse, anaesthesiologists) managing real-life emergencies (postpartum haemorrhage)	Assessment of non-technical skills using a behaviourally anchored rating scale (ATOP; Assessment of Obstetric Team Performance)	Checklist tool for clinical performance (TeamOBS-PPH)
Burtscher, Kolbe, Wacker, et al.[66]	2011	To investigate how team mental models and team monitoring behaviour interact to predict team performance in anaesthesia	Video observation of anaesthesia teams (residents, nurses) conducting a standard anaesthesia induction using a high-fidelity patient simulator	Structured observation of team monitoring behaviour	Checklist based expert rating
Burtscher, Manser, Kolbe, et al.[67]	2011	To investigate the relationship between adaptation of team coordination and clinical performance in response to a critical event	Video observation of anaesthesia teams (resident, nurse) conducting a standard anaesthesia induction including a critical event using a high-fidelity patient simulator	Structured observation of team coordination	Reaction time related to the critical event
Burtscher, Wacker, Grote, et al.[68]	2010	To examine the role of anaesthesia teams' adaptive coordination in managing changing situational demands	Video observation of anaesthesia teams (residents, nurses, students) conducting standard anaesthesia inductions with non-routine events	Structured observation of team coordination	Checklist based expert rating

Carlson, Min, Bridges[10]	2009	To explore the relationship between team behaviour and the delivery of an appropriate standard of care specific to the simulated case	Video observation of trainees participating in a simulated event involving the presentation of acute dyspnoea	Assessment of team behaviour using a behaviourally anchored rating scale (leadership and team behaviour measurement tool)	Checklist based expert rating
Catchpole, Giddings, Wilkinson, et al.[69]	2007	To investigate if effective teamwork can prevent the development of serious situations and provide evidence for improvements in training and systems	Live observation of surgical teams conducting paediatric cardiac and orthopaedic surgeries	Observation of non-technical skills using a behaviourally anchored rating scale (NOTECHS scoring system)	Assessment of minor problems, intraoperative performance and duration of surgery
Catchpole, Mishra, Handa, et al.[70]	2008	To analyse the effects of surgical, aesthetic, and nursing teamwork skills on technical outcomes	Observation of surgical teams conducting laparoscopic cholecystectomies and carotid endarterectomies	Observation of non-technical skills using a behaviourally anchored rating scale (NOTECHS scoring system)	Operating time and errors in surgical technique
Cooper, Wakelam[71]	1999	To examine the relationship between leadership behaviour, team dynamics and task performance	Video observation of emergency teams managing full cardiopulmonary arrests with a resuscitation attempt lasting longer than 3 minutes	Survey about leadership behaviour using the Leadership Behaviour Description Questionnaire	Checklist based expert rating
Davenport, Henderson, Mosca, et al.[72]	2007	To measure the impact of organizational climate safety factors on risk-adjusted surgical morbidity and mortality	Survey of staff on general and vascular surgery services	Survey about teamwork climate, level of communication and collaboration with surgeon	Surgical morbidity Surgical mortality
El Bardissi, Wiegmann, Henrickson, et al.[73]	2008	To identify patterns of teamwork failures that would benefit from intervention in the cardiac surgical setting	Live observation of surgical teams conducting cardiac surgery	Structured observation of teamwork failures that disrupted the flow of the operation	Surgical technical errors
Gillespie, Chaboyer, Fairweather[74]	2012	To investigate how various human factors variables, extend the expected length of an operation	Live observation of surgical teams across 10 specialties	Structured observation of numbers of communication failures	Deviation from expected length of operation

Kolbe, Burtscher, Wacker, et al.[75]	2012	To test the relationship between speaking up and technical team performance in anaesthesia.	Observation of 2-person (nurse, resident) ad hoc anaesthesia teams performing simulated inductions of general anaesthesia with minor nonroutine events	Structured observation of speaking up behaviour	Checklist based expert rating
Kuenzle, Zala-Mezo, Wacker, et al.[76]	2009	To investigate shared leadership patterns during anaesthesia induction and to show how they are linked to team performance	Observation of 2-person (nurse, resident) ad hoc anaesthesia teams performing simulated inductions of general anaesthesia with a nonroutine event (asystole)	Structured observation of leadership behaviour	Reaction time to nonroutine event
Manojilovich, Antonakos, David, et al.[77]	2009	To determine the relationships between patients' outcomes and nurses' perceptions of communication and characteristics of the practice environment.	A survey was conducted with nurses on various ICU wards	Survey about perception of nurse-physician communication using the ICU-nurse physician questionnaire	Ventilator-associated pneumonia Bloodstream infections Pressure ulcers Acute physiology and chronic health evaluation score
Manser, Bogdanovic, Arora, et al.[78]	2015	To investigate surgeons team management skills and its influence on performance	Live observation of surgical teams managing a simulated laparoscopic cholecystectomy	Structured observation of team management using the ComEd-E observation system	Checklist based expert rating
Marsch, Müller, Marquardt, et al.[79]	2004	To determine whether and how human factors affect the quality of cardiopulmonary resuscitation	Observation of healthcare worker (nurse, physician) managing a cardiac arrest due to ventricular fibrillation using a high-fidelity patient simulator	Structured observation of task distribution, information transfer and leadership behaviour within the team	Checklist based expert rating
Mazzocco, Petitti, Fong, et al.[80]	2009	To determine if patients of teams with good teamwork had better outcomes than those with poor teamwork	Live observation of surgical teams managing a variety of surgical procedures	Structured observation of information sharing, inquiry for relevant information and vigilance and awareness using a behaviourally anchored rating scale	Postoperative complications and death

Mishra, Catchpole, Dale, et al.[81]	2008	To report on the development and evaluation of a method for measuring operating-theatre teamwork quality	Live observation of surgical teams conducting laparoscopic cholecystectomy	Assessment of non-technical skills using a behaviourally anchored rating scale (NOTECHS scoring system)	Surgical technical errors assessed with the OCHRA-tool
Schmutz, Hoffmann, Heimberg, et al.[82]	2015	To investigate the moderating effect of task characteristics on the relationship between coordination and performance	Video observation of paediatric teams managing various paediatric emergencies using a high-fidelity patient simulator	Structured observation of closed loop communication, task distribution and provide information without request using the CoMeT-E observation system	Checklist based expert rating
Siassakos, Bristowe, Draycott, et al.[83]	2012	To investigate the relationship between patient satisfaction and communication	Video observation of teams (physicians, midwives) managing obstetric emergencies in secondary and tertiary maternity units	Structured observation of closed loop communication	Timely administration of magnesium sulphate
Siassakos, Fox, Crofts, et al.[84]	2011	To determine whether team performance in a simulated emergency is related to generic teamwork skills and behaviors	Video observation of healthcare professionals (physician, midwives) managing various emergencies using a high-fidelity patient simulator	Assessment of generic teamwork using a behaviourally anchored rating scale (teamwork analytical tool)	Clinical efficiency score
Thomas, Sexton, Lasky, et al.[85]	2006	To investigate the relationship of team behaviours during delivery room care and behaviours relate to the quality of care	Video observation of neonatal care teams managing a resuscitation during a caesarean section	Structured observation of communication, team management and leadership	Compliance with Neonatal Resuscitation Program guidelines
Tschan, Semmer, Gautschi, et al.[86]	2006	To investigate the influence of human factors on team performance in medical emergency driven groups	Video observation of medical emergency teams (senior doctor, resident, nurse) managing a cardiac arrest in a high-fidelity patient simulator	Structured observation of directive leadership and structuring inquiry	Clinical performance assessed based on a time-based coding of observable technical acts

Tschan, Semmer, Gurtner, et al.[87]	2009	To investigate the influence of communication on diagnostic accuracy in ambiguous situations	Video observation of groups of physicians diagnosing a difficult patient with an anaphylactic shock in a high-fidelity patient simulator	Structured observation of the diagnostic information that have been considered, explicit reasoning and talking to the room	Accuracy of diagnosis
Westli, Johnsen, Eid, et al.[88]	2010	To investigate whether demonstrated teamwork skills and behaviour indicating shared mental models would be associated with improved medical management	Video observation of trauma teams (surgeons, anaesthesiologists, nurses, radiographers) in a high-fidelity patient simulator	Assessment of non-technical skills using a behaviourally anchored rating scale (ANTS and ATOM scoring system)	Checklist based expert rating
Wiegmann, El Bardissi, Dearani, et al.[89]	2007	To investigate surgical errors and their relationship to surgical flow disruptions to understand better the effect of these disruptions on surgical errors and patient safety	Live observation of surgical teams conducting cardiac surgery operations	Structured observation of teamwork and communication failures	Structured observation of surgical errors during the operation
Williams, Lasky, Dannemiller, et al.[90]	2010	To describe relationships between teamwork behaviours and errors during neonatal resuscitation	Video observation of intensive care teams managing neonatal resuscitations	Structured observation of teamwork behaviour (vigilance, workload management, information sharing, inquiry, assertion)	Structured observation of errors (non-compliance with guidelines)
Wright, Phillips-Bute, Petrusa, et al.[91]	2009	To test if observer ratings of team skills will correlate with objective measures of clinical performance	Video observation of teams consisting of medical students performing low-fidelity classroom based patient assessment and high-fidelity simulation emergent care.	Observation using a behaviourally anchored rating scale for teamwork skills (assertiveness, decision-making, situation assessment, leadership, communication)	Checklist based expert rating
Yamada, Fuerch, Halamek[92]	2016	To investigate the effect of standardized communication techniques on errors during resuscitation	Video observation of teams (Neonatologists, neonatal nurse practitioners, neonatology fellows) managing neonatal resuscitation	Structured observation of standardised communication	Error rate Time to initiate positive pressure ventilation Time to chest compression

Table 2. Studies, effect sizes and moderator variables included in the meta-analytic database

Authors	Year	Study goal	Participants and setting	No. of teams	Professional composition	Team familiarity	Average team size	Task type	Patient realism	Performance measure
Amacher, Schumacher, Legeret, et al.[64]	2017	.11	Emergency medicine	72	Uniprofessional	Experimental	3	Non-routine	Simulated	Process
Brogaard, Kierkegaard, Hvidmand, et al.[65]	2018	.43	Obstetrics	99	Interprofessional	Real	5	Non-routine	Real	Process
Burtscher, Kolbe, Wacker, et al.[66]	2011	-.27	Anaesthesia	31	Interprofessional	Experimental	2	Routine	Simulated	Process
Burtscher, Manser, Kolbe, et al.[67]	2011	.19	Anaesthesia	15	Interprofessional	Experimental	2	Routine & non-routine	Simulated	Process
Burtscher, Wacker, Grote, et al.[68]	2010	.07	Anaesthesia	22	Interprofessional	Real	3	Non-routine	Real	Process
Carlson, Min, Bridges[10], b	2009	.83	Emergency medicine	44	Uniprofessional	Experimental	2.6	Non-routine	Simulated	Process
Catchpole, Giddings, Wilkinson, et al.[69]	2007	.45†	Surgery	24	Interprofessional	Real	9	Non-routine	Real	Process
	2007	.29†	Surgery	18	Interprofessional	Real	5	Routine	Real	Process
Catchpole, Mishra, Handa, et al.[70]	2008	.36†	Surgery	26	Interprofessional	Real		Routine	Real	Process
	2008	.09†	Surgery	22	Interprofessional	Real		Routine	Real	Process
Cooper, Wakelam[71]	1999	.50	General care	20	Interprofessional	Real	4	Routine	Real	Process
Davenport, Henderson, Mosca, et al.[72]	2007	.17	Surgery	52	Interprofessional	Real		Routine	Real	Outcome
El Bardissi, Wiegmann, Henrickson, et al.[73]	2008	.67	Surgery	31	Interprofessional	Real	7	Routine	Real	Process
Gillespie, Chaboyer, Fairweather[74]	2012	.23	Surgery	160	Interprofessional	Real	6	Routine	Real	Process
Kolbe, Burtscher, Wacker, et al.[75]	2012	.33	Anaesthesia	31	Interprofessional	Real	2	Non-routine	Simulated	Process
Kuenzle, Zala-Mezo, Wacker, et al.[76]	2009	.56	Anaesthesia	12	Interprofessional	Real	2	Routine	Simulated	Process
Manojilovich, Antonakos, David, et al.[77]	2009	.11	Intensive care	25	Uniprofessional	Real	36	Routine	Real	Outcome

Manser, Bogdanovic, Arora, et al.[78]	2015	.39	Surgery	19	Interprofessional	Experi-mental	5	Routine	Simulated	Process
Marsch, Müller, Marquardt, et al.[79]	2004	.23	Intensive care	16	Interprofessional	Experi-mental	3	Non-routine	Simulated	Process
Mazzocco, Petitti, Fong, et al.[80]	2009	.11	Surgery	293	Interprofessional	Real	6	Routine	Real	Outcome
Mishra, Catchpole, Dale, et al.[81]	2008	.05	Surgery	26	Interprofessional	Real	6	Routine	Real	Process
Schmutz, Hoffmann, Heimberg, et al.[82]	2015	.12	Emergency medicine	68	Interprofessional	Real	6	Non-routine	Simulated	Process
Siassakos, Bristowe, Draycott, et al.[83]	2012	.66	Obstetrics	19	Interprofessional	Real	6	Non-routine	Simulated	Process
Siassakos, Fox, Crofts, et al.[84]	2011	.55	Emergency medicine/ obstetrics	24	Interprofessional	Experi-mental	6	Non-routine	Simulated	Process
Thomas, Sexton, Lasky, et al.[85]	2006	.23	Neonatal care	132	Interprofessional	Real	5	Non-routine	Real	Process
Tschan, Semmer, Gautschi, et al.[86]	2006	.23	Emergency medicine	21	Interprofessional	Experi-mental	5	Non-routine	Simulated	Process
Tschan, Semmer, Gurtner, et al.[87]	2009	.37	Emergency medicine	20	Uniprofessional	Experi-mental	2.65	Non-routine	Simulated	Outcome
Westli, Johnsen, Eid, et al.[88]	2010	.18	Emergency medicine	27	Interprofessional	Real	5.1	Non-routine	Simulated	Process
Wiegmann, El Bardissi, Dearani, et al.[89]	2007	.56	Surgery	31	Interprofessional	Real		Routine	Real	Process
Williams, Lasky, Dannemiller, et al.[90]	2010	.18	Neonatal care	12	Interprofessional	Real	5	Non-routine	Real	Process
Wright, Phillips-Bute, Petrusa, et al.[91]	2009	.81	General care	9	Uniprofessional	Experi-mental	4	Non-routine	Simulated	Process
Yamada, Fuerch, Halamek[92]	2016	.11	Emergency medicine	13	Interprofessional	Experi-mental	3	Non-routine	Simulated	Process

[a] Effect sizes (*r*) with an † represent an average for a single sample and a single outcome and have been combined for this meta-analysis.

[b] Carlson, Min & Bridges has been identified as an outlier and therefore excluded from the analysis

Statistical Analysis

Different types of effect sizes (e.g. Odds ratio, F values, and r) have been reported in the original studies. We therefore converted the different effect sizes to a common metric, namely r using the formulas provided by Borenstein et al.[49] and Walker.[50] Moreover, some samples contained effect sizes of teamwork with two or more measures of performance. Because independence of the included effects sizes is required for a meta-analysis,[44,51] we used Fisher's z score to average the multiple correlations from the same sample. The correlations were weighted for sample size. However, in contrast to many meta-analyses in social sciences, the correlations were not adjusted for measurement reliability. This is because information about the measurement reliability could not be compared (Kappa vs. Cronbach Alpha) or were not available at all for the majority of studies. Therefore, we report uncorrected, sample-size weighted mean correlation, its 95% confidence interval (CI), and the 80% credibility interval (CR). The CI reflects the accuracy of a point estimate and can be used to examine the significance of the effect size estimates, whereas the CR refers to the deviation of these estimates and informs us about the existence of possible moderators.

Random-effects models were estimated based on two considerations.[52] First, we expected study heterogeneity to be high given the different study design characteristics such as *patient realism* ("Real patient" vs. "Simulated patient"), *task type* ("Routine task" vs. "Non-routine task"), and different forms of performance measures. Second, we aimed to provide an inference on the average effect in the entire population of studies from which the included studies are assumed to be a random selection of it. Therefore, random-effects models were estimated.[52] These models were calculated by the restricted maximum-likelihood estimator, an efficient and unbiased estimator.[53] Since we included only descriptive studies and no interventions we only included the sample size of the individual studies as a potential bias into the meta-analysis.

The estimation of meta-analytical models including the outlier analyses were performed with the package "metafor" from the programming language and statistical environment R.[52]

RESULTS

The online search resulted in 2002 articles (Figure 1). Based on title and abstract 67 articles were selected for a full text review. Full text examination, forward and backward search of selected articles and relevant reviews resulted in 30 studies coming from 28 articles (Two publications presented two independent studies in one publication[69,70]). Two additional studies were identified via contacting authors directly and have been presented at conferences in the past.[65,78] This led to a total of 32 studies coming from 30 articles. Following suggestions by Viechtbauer and Cheung,[54] outliers were examined using the externally standardized residual score. One case (Carlson et al.,[10] r = .89, n = 44, standardized residual score = 4.26) was identified as outlier and therefore excluded from further analyses, resulting in a final sample size of k = 31.

Table 1 provides a qualitative description of the selected articles including study objectives, the setting in which the studies were carried out and a description of the teamwork processes as well as the outcome measures that were assessed. If a specific tool for the assessment of a teamwork process or outcome measure was used this is indicated in the corresponding column. Observational studies were most prevalent. Teamwork processes were assessed using either behaviourally anchored rating scales (N=8) or structured observation (N=19) of specific teamwork behaviour. Structured observation—as we describe it—is defined as a purely descriptive assessment of certain behaviour usually using a predefined observation system (e.g. amount of speaking up behaviour). In contrast, behaviourally anchored rating scales consist of an evaluation of teamwork process behaviour by an expert. Only three studies used surveys to assess teamwork behaviours. The majority of the studies (*N*=27) assessed process performance using either a checklist-based expert rating or assessing a reaction time measure after the occurrence of a certain event (e.g. time until intervention). Only four studies assessed outcome performance measures (e.g. morbidity, mortality). Table 2 provides an overview of all variables included in the meta-analysis including the effect sizes and moderator variables.

Effect of teamwork and contextual factors

Table 3 shows the relationship between teamwork and team performance. The sample-sized weighted mean correlation was .28 (95% CI: .20 – .35, $z = 6.55$, $p < .001$), indicating that teamwork is positively related to clinical performance. Results further indicated heterogeneous effect size distributions across the included samples ($Q = 53.73$, $p < .05$, $I^2 = 45.96$), signifying that the variability across the sample effect sizes was more than what would be expected from sampling error alone.

To test for moderator effects of the contextual factors, we conducted mixed-effects models including the mentioned moderators: *professional composition, team familiarity, team size, task type, patient realism* and *performance measures.*

The omnibus test of moderators was not significant ($F = 0.18$, $df_1 = 6$, $df_2 = 18$, $p > .20$), suggesting that the examined contextual factors did not influence the average effect of teamwork on clinical performance. To provide greater detail about the role of the contextual factors, we conducted separate analyses for the categorical contextual factors and report them in Table 3.

Table 3. Meta-Analytic relationships between teamwork and clinical performance

	N	k	r	95% CI	80% CR	Q	I^2
Overall relationship	1,390	31	.28	[.20 ; .35]	[.09 ; .45]	53.7	46.0
Team characteristics							
Professional composition							
Interprofessional	1,264	27	.28	[.20 ; .36]	[.09 ; .46]	47.1*	48.2
Uniprofessional	126	4	.28	[-.01 ; .52]	[-.04 ; .54]	6.5	47.1
Team familiarity							
Experimental team	240	10	.25	[.05 ; .43]	[-.05 ; .51]	17.2*	47.2
Real team	1,150	21	.29	[.20 ; .37]	[.12 ; .45]	36.2*	45.7
Team size[a]							
Task characteristics							
Task type							
Routine task	766	14	.27	[.12 ; .40]	[-.01 ; .50]	30.9*	65.0
Non-routine task	609	16	.29	[.20 ; .39]	[.16 ; .42]	20.5	24.6
Methodological factors							
Patient realism							
Real patient	993	16	.28	[.18 ; .38]	[.10 ; .45]	28.7*	49.3
Simulated patient	397	15	.28	[.13 ; .41]	[.02 ; .50]	25.0*	44.6
Performance measures							
Outcome performance	390	4	.13	[.03 ; .23]	[.06 ; .19]	1.3	0.0
Process performance	1,000	27	.30	[.21 ; .39]	[.10 ; .49]	45.6*	45.6

Note. k = number of studies; N = cumulative sample size (number of teams); r = sample-size weighted correlation; CI = confidence interval; CR = credibility interval; Q = test statistic for residual heterogeneity of the models; I^2 = % of total variability in the effect size estimates due to heterogeneity among true effects (vs. sampling error)

[a] Team size was entered as a continuous variable, therefore, no subgroup analyses exist

DISCUSSION

With this study, we quantified the relationship between teamwork and performance in healthcare teams. By including various contextual factors, we investigated potential contingencies that these factors might have on this relationship. The analysis of 1390 teams from 31 different studies showed that teamwork has a medium sized effect (*r*=.28;[55]) on clinical performance across various care settings. Our study is the first to investigate this relationship quantitatively with a meta-analytical procedure. We provide strong evidence that teamwork contributes considerably towards quality of care—or in other words, poor teamwork significantly increases the risk for unsafe care and even patient harm. This finding aligns with and advances previous work that explored this relationship in a qualitative way.[9,16,18,39-43]

The analysis of moderators illustrates that teamwork is related with performance under a variety of conditions. Regardless of team characteristics (professional composition, familiarity, team size) or task type (routine vs. non-routine task), teamwork influences clinical performance. Clinicians and educators from all fields should strive to maintain or increase effective teamwork. Our results suggest that teams in different contexts characterised by different team constellations, team size and levels of acuity of care all benefit from teamwork.

A closer look at methodological factors of the included studies revealed that the observed relationship between teamwork and performance in simulation settings does not differ from relationships observed in real settings. Therefore, we conclude that teamwork studies conducted in simulation settings generalize to real life settings. Further, the analysis of different performance measures reveals a trend towards process performance measures being more strongly related with teamwork than outcome performance measures. A possible explanation of this finding relates to the difficulty of investigating outcome performance measures in a manner isolated from other variables. Nevertheless, we still found a significant relationship between teamwork and objective patient outcomes (e.g. postoperative complications, bloodstream infections) despite the methodological challenges of measuring outcome performance and the small number of studies using outcome performance ($k = 4$).

Our results are in line with previous meta-analyses investigating the effectiveness of team training in healthcare.[19,20] Similar to our results, Hughes et al. highlighted the effectiveness of team trainings under a variety of conditions—irrespective of team composition,[19] simulator fidelity or patient acuity of the trainee's unit as well as other factors.

We were unable to find a moderation of task type in our study, potentially explained by task interdependence, which reflects the degree to which team members depend on one another for their effort, information, and resources.[56] A meta-analysis including teams from multiple industries (e.g. project teams, management teams) found that task interdependence moderates the relationship between teamwork and performance, demonstrating the importance of teamwork for highly interdependent team tasks.[57] Most studies included in our analysis focused on rather short and intense patient care episodes (e.g. a surgery, a resuscitation task) with high task interdependence, which may explain the high relevance of teamwork for all these teams.

Limitations and future directions

Despite greater attention to healthcare team research and team training over the last decade, we were only able to identify 32 studies (31 included in meta-analysis). Of note, over two-thirds of the studies in our analysis emerged in the last 10 years, reflecting the increasing interest in the topic. The rather small number of studies might relate to the difficulties in quantifying teamwork, the considerable theoretical and methodological knowledge required, and the challenges of capturing relevant outcome measures. Future research should build on recent theoretical and applied work[23,24,26,58] about teamwork and use this current meta-analysis as a signpost for future investigations. In order to move our field forward, we must use existing conceptual frameworks[21,23,24] and establish standards for investigating teams and teamwork. This can often only be achieved with interdisciplinary research teams including experts from the medical fields but equally important from health professions education, psychology or communication studies.

Another limitation relates to the unbalanced analysis of subgroups. For example, we only identified four studies that used outcome performance variables compared to 27 using process performance measures. Uneven groups may reduce the power to detect significant differences. Therefore, we encourage future studies to include outcome performance measures despite the effort required.

Moreover, we cannot rule out a file-drawer effect, meaning that we probably could not find and include all unpublished studies, a common downside of meta-analysis.[37] Unpublished studies more often report nonsignificant results.

Finally, more factors may influence the relationship between teamwork and performance that we were unable to extract from the studies. While we tested for the effects of team familiarity by comparing experimental teams and real teams, this does not fully capture team member familiarity. The extent to which team members actually worked together during prior clinical practice might predict of how effectively they perform together. However, even two people working in the same ward might actually not have interacted much during patient care depending on the setting. Further, also team climate on a ward or in a hospital may be an important predictor of how well teams work together, especially related to sharing information or speaking up within the team.[59,60] Unfortunately we were not able to extract this information from the primary studies. Therefore, future work needs to consider and also document a broader range of potentially influencing factors.

Conclusion

The current meta-analysis confirms that teamwork across various team compositions represents a powerful process to improve patient care. Good teamwork can be achieved by joint reflection about teamwork during clinical event debriefings[61,62] as well as team trainings[63] and system improvement. All healthcare organisations should recognise these findings and place continuous efforts into maintaining and improving teamwork for the benefit of their patients.

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Ethics approval: Not required

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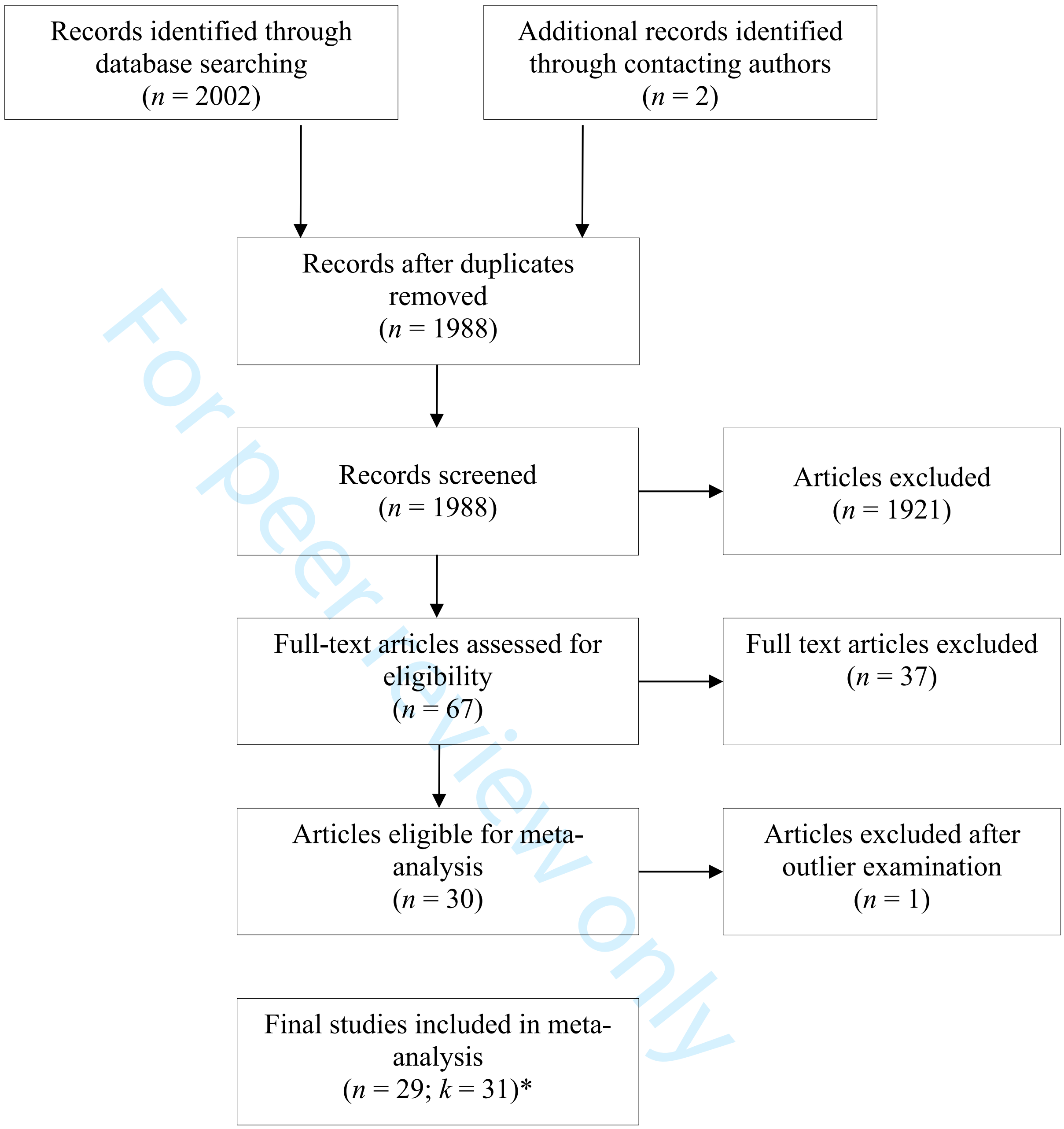
Figure 1. Systematic literature search.



*The search identified 31 studies published in 29 articles

SUPPLEMENTARY FILE

Article: **How effective is teamwork really? The relationship between teamwork and performance in healthcare teams: A systematic review and meta-analysis**

Jan B. Schmutz, PhD, Laurenz L. Meier, PhD, Tanja Manser, PhD

Search terms used for PubMed search

(Teamwork[All Fields]) OR (team[All Fields] AND coordination[All Fields]) OR (team[All Fields] AND "decision making"[All Fields]) OR ((team[All Fields]) AND (communication[MeSH Terms]) OR (communication[All Fields])) OR (team[All Fields] AND leadership[All Fields]) AND (patient safety[MeSH Terms])

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4-8
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4-5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	n/a
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	9-10
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	9
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	9 and supplemental material
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	9-10
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	10
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	9-12
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	20
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	13-19 / 23

PRISMA 2009 Checklist

Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	20-23

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	20,26
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	22-23
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	21
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	18-19
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	18-19, 20
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	13-19
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	23
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	23
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	N/A
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	24-27
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	26-27
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	27
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	28

PRISMA 2009 Checklist

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

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How effective is teamwork really? The relationship between teamwork and performance in healthcare teams: A systematic review and meta-analysis

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How effective is teamwork really? The relationship between teamwork and performance in healthcare teams: A systematic review and meta-analysis

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ABSTRACT

Objectives To investigate the relationship between teamwork and clinical performance and potential moderating variables of this relationship.

Design Systematic review and meta-analysis.

Methods Data sources were searched up to June 2018 and included PubMed, manual backward search of relevant reviews, manual backward and forward search of studies included in the meta-analysis and contacting of selected authors via e-mail. Studies were included if they reported a relationship between a teamwork process and a performance measure. Moderator variables (i.e. professional composition, team familiarity, average team size, task type, patient realism and type of performance measure) were coded and random-effect models were estimated. Two investigators independently extracted information on study characteristics in accordance with PRISMA guidelines.

Results The review identified 2002 articles of which 31 were included in the meta-analysis comprising 1390 teams. The sample-sized weighted mean correlation was $r = .28$, indicating that teamwork is positively related to performance. The test of moderators was not significant, suggesting that the examined factors did not influence the average effect of teamwork on performance.

Conclusion Teamwork has a medium-sized effect on performance. The analysis of moderators illustrated that teamwork relates to performance regardless of characteristics of the team or task. Therefore, healthcare organizations should recognize the value of teamwork and emphasize approaches that maintain and improve teamwork for the benefit of their patients.

ARTICLE SUMMARY

Strengths and limitations of this study

- This systematic review evaluates available studies investigating the effectiveness of teamwork processes.
- 31 studies have been included resulting in a substantial sample size of 1390 teams.
- The sample size of the primary studies included is usually low.
- For some subgroup analysis, the number of studies included was small.

INTRODUCTION

May it be an emergency team in the trauma room, paramedics treating patients after an accident or a surgical team in the operating room, teams are ubiquitous in healthcare and must work across professional, disciplinary and sectorial boundaries. Although the clinical expertise of individual team members is important to ensure high performance, teams must be capable of applying and combining the unique expertise of team members to maintain safety and optimal performance. In order for a team to be effective individual team members need to collaborate and engage in teamwork. Today, experts agree that effective teamwork anchors safe and effective care at various levels of the healthcare systems[1-4] leading to a relatively recent shift towards team research and training.[5-7]

Healthcare is an evidence-based field and therefore administrators and providers are seeking evidence in the literature concerning the impact of teamwork on performance outcomes like patient mortality, morbidity, infection rates or adherence to clinical treatment guidelines. Having a closer look at the literature investigating healthcare teams we find mixed and sometimes even contradicting results about the relationship between teamwork and clinical performance.[8] Some studies find a large effect of teamwork on performance outcomes (e.g. Carlson et al.[9]) while others report small or no relationships.[10,11] This inconsistency arises due to several reasons. First, the conceptual and empirical literature examining teamwork is fragmented and research examining teamwork effectiveness is spread across disciplines including medicine, psychology and organization science. Therefore, researchers and practitioners often lack a common conceptual foundation for investigating teams and teamwork in healthcare. Second, research studies on teamwork in healthcare usually exhibit small sample sizes because of the challenges of recruiting actual professional teams and carefully balancing research with patient

care priorities. Small sample sizes, however, increase the likelihood of reporting results that fail to represent true effect. Third, studies investigating healthcare teams often ignore important context variables of teams (e.g. team composition and size, task characteristics, team environment) that likely influence the effect that teamwork has on clinical performance.[12,13]

These inconsistencies in the teamwork literature may lead to confusion about the importance of teamwork in healthcare, thus giving voice to critics who hinder efforts to improve teamwork. We aim to address these problems with a meta-analytical study investigating the performance implications of teamwork. A meta-analytical approach moves beyond existing reviews on teamwork in healthcare[8,14-17] and quantitatively tests if the widely advocated positive effect of teamwork on performance holds true. In addition, this approach allows us to investigate context variables as moderators that may influence the effect of teamwork on performance, meaning that this effect might be stronger or weaker under certain conditions. Previous meta-analyses[18,19] focused mainly on the effectiveness of team trainings but not on the effect of teamwork itself. This meta-analysis will generate quantitative evidence to inform the relevance of future interventions, regulations and policies targeting teamwork in healthcare organizations.

In the following we will first establish an operational definition of teamwork, elaborate on relevant contextual factors, and present our respective meta-analytic results and their interpretation.

Teams, teamwork and team performance

In order to clearly understand the impact of teamwork on performance it is necessary to provide a brief introduction to teams, teamwork and team performance. We define teams as identifiable social work units consisting of two or more people with several unique

characteristics. These characteristics include *a)* dynamic social interaction with meaningful interdependencies; *b)* shared and valued goals*, c)* a discrete lifespan, *e)* distributed expertise and *f)* clearly assigned roles and responsibilities.[20,21] Based on this definition it becomes clear that teams must dynamically share information and resources amongst members and coordinate their activities in order to fulfil a certain task—in other words teams need to engage in *teamwork.*

Teamwork as a term is widely used and often difficult to grasp. However, we absolutely require a clear definition of teamwork especially for team trainings that target specific behaviours. *Teamwork* is a process that describes interactions among team members who combine collective resources to resolve task demands (e.g. giving clear orders).[22,23] Teamwork or team processes can be differentiated from *taskwork*. *Taskwork* denotes a team's individual interaction with tasks, tools, machines and systems.[23] *Taskwork* is independent of other team members and is often described as *what* a team is doing whereas *teamwork* is *how* the members of a team are doing something with each other.[24] Therefore, *team performance* represents the accumulation of teamwork and taskwork (i.e. what the team actually does).[25]

Team performance is often described in terms of inputs, processes and outputs (IPO).[22,26-28] *Outputs* like quality of care, errors or performance are influenced by team related *processes* (i.e. teamwork) like communication, coordination or decision making. Furthermore, these processes are influenced by various *inputs* like team members' experience, task complexity, time pressure and more. The IPO framework emphasizes the critical role of team processes as the mechanism by which team members combine their resources and abilities, shaped by the context, to resolve team task demands. It has been the basis of other more advanced models[27-29] but has also been criticized because of its simplicity.[30] However, it is still the most popular

framework to date and helps to systematize the mechanisms that predict team performance and represents the basis for the selection of the studies included in our meta-analysis.

Contextual factors of teamwork effectiveness

Based on a large body of team research from various domains, we hypothesize that several contextual and methodological factors might moderate the effectiveness of teamwork, indicating that teamwork is more important under certain conditions.[31,32] Therefore, we investigate several factors: (a) team characteristics (i.e. professional composition, team familiarity, team size); (b) task type (i.e. routine vs. non-routine tasks); (c) two methodological factors related to patient realism (i.e. simulated vs. real) and the type of performance measures used (i.e. process vs. outcome performance). In the following we discuss these potentially moderating factors and the proposed effects on teamwork.

Professional composition. We distinguished between interprofessional and uniprofessional teams. Interprofessional teams consist of members from various professions that must work together in a coordinated fashion.[33] Diverse educational paths in interprofessional teams may shape respective values, beliefs, attitudes and behaviours.[34] As a result team members with different backgrounds might perceive and interpret the environment differently and have a different understanding of how to work together. Therefore, we assume that explicit teamwork is especially important in interprofessional teams compared to uniprofessional teams.

Team familiarity. If team members have worked together, they are familiar with their individual working styles; and roles and responsibilities are usually clear. If a team works together for the first time, this potential lack of familiarity and clarity might make teamwork even more important. Therefore, we differentiate between *real teams* that also work together in

their everyday clinical practice and *experiential teams* that only came together for study purposes.

Team size. Another factor that may moderate the relationship between teamwork and performance is team size. Since larger teams exhibit more linkages among members than smaller teams, they also face greater coordination challenges. Also, with increasing size teams have greater difficulty developing and maintaining role structures and responsibilities. For these reasons, we expect the influence of teamwork on clinical performance to be stronger in larger teams as compared to smaller teams.

Task type. Routine situations are characterized by repetitive and unvarying actions (e.g. standard anaesthesia induction).[35] In contrast, non-routine situations exhibit more variation and uncertainty, requiring teams to be flexible and adaptive. Whereas team members mostly rely on pre-learned sequences during routine situations, during non-routine situations we assume that teamwork is more important in order for team members to resolve task demands.

Patient realism. Authors highlight the importance of using medical simulators in education.[36] Therefore, we investigate the realism used in a study (simulated vs. real patients) as a potential methodological factor that influences the relationship between teamwork and performance. Studies conducted with medical simulators might be more standardized and less influenced by confounding variables than studies conducted with real patients. Therefore, results from simulation studies might show stronger relationships between the two variables. Further, using a simulator could cause individuals and teams to act differently than in real settings, thereby distorting the results. However, in the last decade high-fidelity simulators have become increasingly realistic, suggesting that the results from simulation studies generalize to real environments. Including realism as a contextual factor in our analysis will reveal if the effects of

teamwork observed in simulation compare with real life settings. Better understanding would provide important insights about simulation use in teamwork studies.

Performance measures. As a second methodological factor, we expect that the type of performance measure used in a study influences the reported teamwork effectiveness. The literature usually differentiates between process- and outcome-related aspects of performance.[37,38] Process performance measures are action-related aspects and refer to adequate behaviour during procedures (e.g. adhering to guidelines), making them easier to assess. Outcome performance measures (e.g. infection rates after operations) follow team actions, with assessment occurring later than process measures. Outcome performance measures suffer from several factors: greater sensitivity to confounding variables (e.g. comorbidities), assessment challenges, and greater difficulty linking team processes to outcomes. Looking at the predictors of the survival of cardiac arrest patients illustrates the difference between the two types of performance measures. The main predictors for the survival (i.e. performance outcome) of a cardiac arrest patient are *"duration of the arrest"* and *"age of the patient less than 70"*.[39] Although a team delivers perfect basic life support (i.e. high process performance) the patient can still die (i.e. low outcome performance). Due to these methodological considerations, we expect that studies assessing process performance report a stronger relationship between teamwork and performance than studies assessing outcome performance.

METHODS

The study was conducted based on the recommendations of the PRISMA statement[40] as well as established guidelines in social sciences.[41,42] Through the combination of studies in the meta-analytical process, we will increase the statistical power and provide an accurate estimation of the true impact that teamwork has on performance.

Search strategy

We applied the following search strategy to select relevant papers: *a)* an electronic search of the data base PubMed (no limit was placed on date of publication, last search June 2018) using the key words *teamwork*, *coordination*, *decision making*, *leadership* and *communication* in combination with *patient safety*, *clinical performance*, the final syntax for PubMed is available online (Supplementary File), b) a manual backwards search for all references cited by 8 systematic literature reviews that focus on teamwork or non-technical skills in various healthcare domains,[8,15,17,43-47] c) a manual backwards search for all references cited in studies we included in our meta-analysis, d) a manual forward search using Web of Science to identify studies that cite the studies we included in our meta-analysis, e) identification of relevant unpublished manuscripts via e-mail from authors currently investigating medical teams using specific mailing lists.

Inclusion criteria

Studies were included if a construct complied to the definition of teamwork processes outlined in the introduction (e.g. coordination, communication). In addition, studies needed to investigate the relationship between at least one teamwork process and a performance measure (e.g. patient outcome). When studies reported multiple estimates of the same relationship from

the same sample (e.g. between coordination and more than one indicator of performance), those correlations were examined separately only as appropriate for sub-analyses, but an average correlation was computed for all global meta-analyses of those relationships to maintain independence.[41] We excluded articles investigating long-term care since the dynamics of teamwork over a longer period of time are different. All articles included in this meta-analysis are listed in Table 1 and Table 2.

For the criterion level of analysis, we included only effect sizes at the team level and not on an individual level. Therefore, the performance measure had to be clearly linked to a team. This approach aligns with research that strongly recommends against mixing levels of analysis in meta-analytic integrations.[48,49]

Two reviewers independently screened titles and abstracts from articles yielded in the search. Afterwards full texts of all relevant articles were obtained and screened by the same two reviewers. Agreement was above 90%. Any disagreement in the selection process was resolved through consensus discussion.

Data extraction

With the help of a jointly developed coding scheme, studies were independently coded by one of the authors (JS) and another rater, both with a background in industrial psychology and human factors. 20% of the studies were rated by both coders. Intercoder agreement was above 90%. Any disagreement was resolved through discussion. The data extracted comprised details of the authors and publication as well as important study characteristics and statistical relationships between a teamwork variable and performance (Table 2).

Coding of team characteristics

The *professional composition* of teams was coded either as “Interprofessional” if a team consisted of members from different professions (e.g. nurses and physicians) or as “Uniprofessional” if the members of the teams were of the same profession. *Team size* was coded as the number of members (average number if team size varied) of the investigated teams. Team familiarity was coded either as “experimental” or “real”. “Real” indicates that the team members also worked together in their everyday clinical practice. “Experimental” means that the teams only worked together during the study.

Coding of task characteristics

Task type was coded either as “Routine task” or “Non-routine task”. We defined “Non-routine tasks” as unexpected events that require flexible behavior often under time-pressure (e.g. emergency situations). “Routine tasks” describe previously planned standard procedures (e.g. standard anesthesia induction, planned surgery).

Coding of methodological factors

Patient realism was either coded as “Real patient” or “Simulated patient”. “Simulated patient” included a patient simulator (manikin) whereas “Real patient” included real patients in clinical settings.

Clinical performance measures were coded either as “Outcome performance” or “Process performance”.[38,50] “Outcome performance” includes an outcome that is measured after the treatment process (e.g. infection rate, mortality). We focused only on patient-related outcomes and not on team outcomes (e.g. team satisfaction). “Process performance” describes the evaluation of the treatment process and describes how well the process was executed (e.g.

adherence to guidelines through expert rating). Process performance measures are often based on official guidelines and extensive expert knowledge.[51] Thus, we assumed that process performance closely relates to patient outcomes.

Statistical Analysis

Different types of effect sizes (e.g. Odds ratio, *F* values, and *r*) have been reported in the original studies. We therefore converted the different effect sizes to a common metric, namely *r* using the formulas provided by Borenstein et al.[52] and Walker.[53] Moreover, some samples contained effect sizes of teamwork with two or more measures of performance. Because independence of the included effects sizes is required for a meta-analysis,[41,54] we used Fisher's z score to average the multiple correlations from the same sample. The correlations were weighted for sample size. However, in contrast to many meta-analyses in social sciences, the correlations were not adjusted for measurement reliability. This is because information about the measurement reliability could not be compared (Kappa vs. Cronbach Alpha) or were not available at all for the majority of studies. Therefore, we report uncorrected, sample-size weighted mean correlation, its 95% confidence interval (CI), and the 80% credibility interval (CR). The CI reflects the accuracy of a point estimate and can be used to examine the significance of the effect size estimates, whereas the CR refers to the deviation of these estimates and informs us about the existence of possible moderators.

Random-effects models were estimated based on two considerations.[55] First, we expected study heterogeneity to be high given the different study design characteristics such as *patient realism* ("Real patient" vs. "Simulated patient"), *task type* ("Routine task" vs. "Non-routine task"), and different forms of performance measures. Second, we aimed to provide an inference on the average effect in the entire population of studies from which the included studies are assumed to be a random selection of it. Therefore, random-effects models were estimated.[55] These models were calculated by the restricted maximum-likelihood estimator, an efficient and unbiased estimator.[56] Since we included only descriptive studies and no interventions we only included the sample size of the individual studies as a potential bias into the meta-analysis. To rule out a potential publication bias, we tested for funnel plot asymmetry using the random-effect version of the Egger test.[57] The results indicate that there is no asymmetry in the funnel plot ($z = 1.79$, $p = .074$), suggesting that there is no publication bias.

The estimation of meta-analytical models including the outlier analyses were performed with the package “metafor” from the programming language and statistical environment R.[55]

Patient and public involvement

Patients and public were not involved in this study.

RESULTS

The online search resulted in 2002 articles (Figure 1). Based on title and abstract 67 articles were selected for a full text review. Full text examination, forward and backward search of selected articles and relevant reviews resulted in 30 studies coming from 28 articles (Two publications presented two independent studies in one publication[58,59]). Two additional studies were identified via contacting authors directly and have been presented at conferences in the past.[60,61] This led to a total of 32 studies coming from 30 articles. One case (Carlson et al.,[9] $r = .89$, $n = 44$, standardized residual score = 4.26) was identified as outlier and therefore excluded from further analyses, resulting in a final sample size of $k = 31$.

Table 1 provides a qualitative description of the selected articles including study objectives, the setting in which the studies were carried out and a description of the teamwork processes as well as the outcome measures that were assessed. If a specific tool for the assessment of a teamwork process or outcome measure was used this is indicated in the corresponding column. Observational studies were most prevalent. Teamwork processes were assessed using either behaviourally anchored rating scales (N=8) or structured observation (N=19) of specific teamwork behaviour. Structured observation—as we describe it—is defined as a purely descriptive assessment of certain behaviour usually using a predefined observation system (e.g. amount of speaking up behaviour). In contrast, behaviourally anchored rating scales consist of an evaluation of teamwork process behaviour by an expert. Only three studies used surveys to assess teamwork behaviours. The majority of the studies (N=27) assessed process performance using either a checklist-based expert rating or assessing a reaction time measure after the occurrence of a certain event (e.g. time until intervention). Only four studies assessed outcome performance measures. Measures included accuracy of diagnosis, postoperative complications and death, surgical morbidity and mortality, ventilator-associated pneumonia, bloodstream infections, pressure ulcers and acute physiology and chronic health evaluation score. Table 2 provides an overview of all variables included in the meta-analysis including the effect sizes and moderator variables.

Effect of teamwork and contextual factors

Table 3 and Figure 2 shows the relationship between teamwork and team performance. The sample-sized weighted mean correlation was .28 (95% CI: .20 to .35, $z = 6.55$, $p < .001$), indicating that teamwork is positively related to clinical performance. Results further indicated heterogeneous effect size distributions across the included samples ($Q = 53.73$, $p < .05$, $I^2 =$

45.96), signifying that the variability across the sample effect sizes was more than what would be expected from sampling error alone.

To test for moderator effects of the contextual factors, we conducted mixed-effects models including the mentioned moderators: *professional composition, team familiarity, team size, task type, patient realism* and *performance measures.*

The omnibus test of moderators was not significant ($F = 0.18$, $df_1 = 6$, $df_2 = 18$, $p > .20$), suggesting that the examined contextual factors did not influence the average effect of teamwork on clinical performance. To provide greater detail about the role of the contextual factors, we conducted separate analyses for the categorical contextual factors and report them in Table 3.

DISCUSSION

With this study, we aimed to provide evidence for the performance implications of teamwork in healthcare teams. By including various contextual factors, we investigated potential contingencies that these factors might have on the relationship between teamwork and clinical performance. The analysis of 1390 teams from 31 different studies showed that teamwork has a medium sized effect (r=.28; [62,63]) on clinical performance across various care settings. Our study is the first to investigate this relationship quantitatively with a meta-analytical procedure. This finding aligns with and advances previous work that explored this relationship in a qualitative way.[8,15,17,43-47]

At first glance a correlation of r=.28 might not seem very high. However, we would like to highlight that r=.28 is considered a medium sized effect[62,63] and should not be underestimated. To better illustrate what this effect means we transformed the correlation into an odds ratio (OR) of 2.8.[52] Of course, this transformation simplifies the correlation because teamwork and often the outcome measures are not simple dichotomous variables that can be divided into an intervention and control group. However, this transformation illustrates that teams who engage in teamwork processes are 2.8 times more likely to achieve high performance than teams who are not. Looking at the performance measures in our study we see that they either describe patient outcomes (e.g. mortality, morbidity) or are closely related to patient outcomes (e.g. adherence to treatment guidelines). Thus, we consider teamwork a performance-relevant process that needs to be promoted through training and implementation into treatment guidelines and policies.

The included studies used a variety of different measures for clinical performance. This variability resulted from the different clinical contexts in which the studies were carried out.

There is no universal measure for clinical performance because the outcome is in most cases context specific. In surgery, common performance measures are surgical complications, mortality or morbidity.[64] In anaesthesia, studies often use expert ratings based on checklists to assess the provision of anaesthesia. Expert ratings are also the common form of performance assessment in simulator settings where patient outcomes like morbidity or mortality cannot be measured. Future studies need to be aware that clinical performance measures depend on the clinical context and that the development of valid performance measures requires considerable effort and scientific rigor. Guidelines on how to develop performance assessment tools for specific clinical scenarios exist and need to be accounted for.[51,65,66] Furthermore, depending on the clinical setting researchers need to evaluate what specific clinical performance measures are suitable and if and how they can be linked to team processes in a meaningful way.

The analysis of moderators illustrates that teamwork is related with performance under a variety of conditions. Our results suggest that teams in different contexts characterised by different team constellations, team size and levels of acuity of care all benefit from teamwork. Therefore, clinicians and educators from all fields should strive to maintain or increase effective teamwork. In recent years, there has been an upsurge in crisis resource management (CRM).[19] These trainings focus on team management and implement various teamwork principles during crisis situations (e.g. emergencies).[67] Our results suggest that team trainings should not only focus on non-routine situations like emergencies but also on routine situations (e.g. routine anaesthesia induction, routine surgery) because based on our data teamwork is equally important in such situations.

A closer look at methodological factors of the included studies revealed that the observed relationship between teamwork and performance in simulation settings does not differ from

relationships observed in real settings. Therefore, we conclude that teamwork studies conducted in simulation settings generalize to real life settings. Further, the analysis of different performance measures reveals a trend towards process performance measures being more strongly related with teamwork than outcome performance measures. A possible explanation of this finding relates to the difficulty of investigating outcome performance measures in a manner isolated from other variables. Nevertheless, we still found a significant relationship between teamwork and objective patient outcomes (e.g. postoperative complications, bloodstream infections) despite the methodological challenges of measuring outcome performance and the small number of studies using outcome performance ($k = 4$).

Our results are in line with previous meta-analyses investigating the effectiveness of team training in healthcare.[18,19] Similar to our results, Hughes et al. highlighted the effectiveness of team trainings under a variety of conditions—irrespective of team composition,[18] simulator fidelity or patient acuity of the trainee's unit as well as other factors.

We were unable to find a moderation of task type in our study, potentially explained by task interdependence, which reflects the degree to which team members depend on one another for their effort, information, and resources.[68] A meta-analysis including teams from multiple industries (e.g. project teams, management teams) found that task interdependence moderates the relationship between teamwork and performance, demonstrating the importance of teamwork for highly interdependent team tasks.[69] Most studies included in our analysis focused on rather short and intense patient care episodes (e.g. a surgery, a resuscitation task) with high task interdependence, which may explain the high relevance of teamwork for all these teams.

Limitations and future directions

Despite greater attention to healthcare team research and team training over the last decade, we were only able to identify 32 studies (31 included in the meta-analysis). Of note, over two-thirds of the studies in our analysis emerged in the last 10 years, reflecting the increasing interest in the topic. The rather small number of studies might relate to the difficulties in quantifying teamwork, the considerable theoretical and methodological knowledge required, and the challenges of capturing relevant outcome measures. Also, besides the manual searches of selected articles and reviews and contacting authors in the field we did only search the data base PubMed.

Future research should build on recent theoretical and applied work[24,26,28,70] about teamwork and use this current meta-analysis as a signpost for future investigations. In order to move our field forward, we must use existing conceptual frameworks[22,24,26] and establish standards for investigating teams and teamwork. This can often only be achieved with interdisciplinary research teams including experts from the medical fields but equally important from health professions education, psychology or communication studies.

Another limitation relates to the unbalanced analysis of subgroups. For example, we only identified four studies that used outcome performance variables compared to 27 using process performance measures. Uneven groups may reduce the power to detect significant differences. Therefore, we encourage future studies to include outcome performance measures despite the effort required.

Finally, more factors may influence the relationship between teamwork and performance that we were unable to extract from the studies. While we tested for the effects of team familiarity by comparing experimental teams and real teams, this does not fully capture team member familiarity. The extent to which team members actually worked together during prior clinical practice might predict of how effectively they perform together. However, even two people working in the same ward might actually not have interacted much during patient care depending on the setting. Also team climate on a ward or in a hospital may be an important predictor of how well teams work together, especially related to sharing information or speaking up within the team.[71,72]

Finally, the clinical context might play a role in how team members collaborate. In different disciplines, departments or healthcare institutions different norms and routines exist on how to work together. Therefore study results and recommendations about teamwork need to be interpreted in the light of the respective clinical context. There are empirical indications that a one-size-fits-all approach might not be suitable and team training efforts cannot ignore the clinical context, especially the routines and norms about collaboration.[73] We acknowledge that there might be other factors surrounding healthcare teams that might potentially influence teamwork and clinical performance. However, in this review we could only extract data that was reported in the primary studies. Since these were limited in the healthcare contexts studied, the results might not generalise to long-term care settings or mental health, for example. Future work needs to consider and also document a broader range of potentially influencing factors.

Conclusion

The current meta-analysis confirms that teamwork across various team compositions represents a powerful process to improve patient care. Good teamwork can be achieved by joint reflection about teamwork during clinical event debriefings[74,75] as well as team trainings[76] and system improvement. All healthcare organisations should recognise these findings and place continuous efforts into maintaining and improving teamwork for the benefit of their patients.

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Table 1. Descriptions of study objectives, settings and description of teamwork process and outcome measures

Authors	Year	Main study objectives	Participants and setting	Teamwork process measure	Outcome measure
Amacher, Schumacher, Legeret, et al.[77]	2017	To compare female and male rescuers in regard to cardiopulmonary resuscitation and leadership performance	Video observation of medical students managing cardiopulmonary resuscitation in a high-fidelity patient simulator	Structured observation of secure leadership statements within teams	Time until start chest compression Hands-on time within first 180 seconds
Brogaard, Kierkegaard, Hvidmand, et al.[60]	2018	To investigate the relationship between non-technical skills and clinical performance in obstetric teams	Video observation of obstetric teams (Obstetricians, obstetric nurse, anaesthesiologists) managing real-life emergencies (postpartum haemorrhage)	Assessment of non-technical skills using a behaviourally anchored rating scale (ATOP; Assessment of Obstetric Team Performance)	Checklist tool for clinical performance (TeamOBS-PPH)
Burtscher, Kolbe, Wacker, et al.[78]	2011	To investigate how team mental models and team monitoring behaviour interact to predict team performance in anaesthesia	Video observation of anaesthesia teams (residents, nurses) conducting a standard anaesthesia induction using a high-fidelity patient simulator	Structured observation of team monitoring behaviour	Checklist based expert rating
Burtscher, Manser, Kolbe, et al.[79]	2011	To investigate the relationship between adaptation of team coordination and clinical performance in response to a critical event	Video observation of anaesthesia teams (resident, nurse) conducting a standard anaesthesia induction including a critical event using a high-fidelity patient simulator	Structured observation of team coordination	Reaction time related to the critical event
Burtscher, Wacker, Grote, et al.[80]	2010	To examine the role of anaesthesia teams' adaptive coordination in managing changing situational demands	Video observation of anaesthesia teams (residents, nurses, students) conducting standard anaesthesia inductions with non-routine events	Structured observation of team coordination	Checklist based expert rating

Carlson, Min, Bridges[9]	2009	To explore the relationship between team behaviour and the delivery of an appropriate standard of care specific to the simulated case	Video observation of trainees participating in a simulated event involving the presentation of acute dyspnoea	Assessment of team behaviour using a behaviourally anchored rating scale (leadership and team behaviour measurement tool)	Checklist based expert rating
Catchpole, Giddings, Wilkinson, et al.[58]	2007	To investigate if effective teamwork can prevent the development of serious situations and provide evidence for improvements in training and systems	Live observation of surgical teams conducting paediatric cardiac and orthopaedic surgeries	Observation of non-technical skills using a behaviourally anchored rating scale (NOTECHS scoring system)	Assessment of minor problems, intraoperative performance and duration of surgery
Catchpole, Mishra, Handa, et al.[59]	2008	To analyse the effects of surgical, aesthetic, and nursing teamwork skills on technical outcomes	Observation of surgical teams conducting laparoscopic cholecystectomies and carotid endarterectomies	Observation of non-technical skills using a behaviourally anchored rating scale (NOTECHS scoring system)	Operating time and errors in surgical technique
Cooper, Wakelam[81]	1999	To examine the relationship between leadership behaviour, team dynamics and task performance	Video observation of emergency teams managing full cardiopulmonary arrests with a resuscitation attempt lasting longer than 3 minutes	Survey about leadership behaviour using the Leadership Behaviour Description Questionnaire	Checklist based expert rating
Davenport, Henderson, Mosca, et al.[82]	2007	To measure the impact of organizational climate safety factors on risk-adjusted surgical morbidity and mortality	Survey of staff on general and vascular surgery services	Survey about teamwork climate, level of communication and collaboration with surgeon	Surgical morbidity Surgical mortality
El Bardissi, Wiegmann, Henrickson, et al.[83]	2008	To identify patterns of teamwork failures that would benefit from intervention in the cardiac surgical setting	Live observation of surgical teams conducting cardiac surgery	Structured observation of teamwork failures that disrupted the flow of the operation	Surgical technical errors
Gillespie, Chaboyer, Fairweather[84]	2012	To investigate how various human factors variables, extend the expected length of an operation	Live observation of surgical teams across 10 specialties	Structured observation of numbers of communication failures	Deviation from expected length of operation

Kolbe, Burtscher, Wacker, et al.[85]	2012	To test the relationship between speaking up and technical team performance in anaesthesia.	Observation of 2-person (nurse, resident) ad hoc anaesthesia teams performing simulated inductions of general anaesthesia with minor nonroutine events	Structured observation of speaking up behaviour	Checklist based expert rating
Kuenzle, Zala-Mezo, Wacker, et al.[86]	2009	To investigate shared leadership patterns during anaesthesia induction and to show how they are linked to team performance	Observation of 2-person (nurse, resident) ad hoc anaesthesia teams performing simulated inductions of general anaesthesia with a nonroutine event (asystole)	Structured observation of leadership behaviour	Reaction time to nonroutine event
Manojilovich, Antonakos, David, et al.[87]	2009	To determine the relationships between patients' outcomes and nurses' perceptions of communication and characteristics of the practice environment.	A survey was conducted with nurses on various ICU wards	Survey about perception of nurse-physician communication using the ICU-nurse physician questionnaire	Ventilator-associated pneumonia Bloodstream infections Pressure ulcers Acute physiology and chronic health evaluation score
Manser, Bogdanovic, Clack, et al. [61]	2015	To investigate surgeons team management skills and its influence on performance	Live observation of surgical teams managing a simulated laparoscopic cholecystectomy	Structured observation of team management using the ComEd-E observation system	Checklist based expert rating
Marsch, Müller, Marquardt, et al.[88]	2004	To determine whether and how human factors affect the quality of cardiopulmonary resuscitation	Observation of healthcare worker (nurse, physician) managing a cardiac arrest due to ventricular fibrillation using a high-fidelity patient simulator	Structured observation of task distribution, information transfer and leadership behaviour within the team	Checklist based expert rating
Mazzocco, Petitti, Fong, et al.[89]	2009	To determine if patients of teams with good teamwork had better outcomes than those with poor teamwork	Live observation of surgical teams managing a variety of surgical procedures	Structured observation of information sharing, inquiry for relevant information and vigilance and awareness using a behaviourally anchored rating scale	Postoperative complications and death

Mishra, Catchpole, Dale, et al.[90]	2008	To report on the development and evaluation of a method for measuring operating-theatre teamwork quality	Live observation of surgical teams conducting laparoscopic cholecystectomy	Assessment of non-technical skills using a behaviourally anchored rating scale (NOTECHS scoring system)	Surgical technical errors assessed with the OCHRA-tool
Schmutz, Hoffmann, Heimberg, et al.[91]	2015	To investigate the moderating effect of task characteristics on the relationship between coordination and performance	Video observation of paediatric teams managing various paediatric emergencies using a high-fidelity patient simulator	Structured observation of closed loop communication, task distribution and provide information without request using the CoMeT-E observation system	Checklist based expert rating
Siassakos, Bristowe, Draycott, et al.[92]	2012	To investigate the relationship between patient satisfaction and communication	Video observation of teams (physicians, midwives) managing obstetric emergencies in secondary and tertiary maternity units	Structured observation of closed loop communication	Timely administration of magnesium sulphate
Siassakos, Fox, Crofts, et al.[93]	2011	To determine whether team performance in a simulated emergency is related to generic teamwork skills and behaviors	Video observation of healthcare professionals (physician, midwives) managing various emergencies using a high-fidelity patient simulator	Assessment of generic teamwork using a behaviourally anchored rating scale (teamwork analytical tool)	Clinical efficiency score
Thomas, Sexton, Lasky, et al.[94]	2006	To investigate the relationship of team behaviours during delivery room care and behaviours relate to the quality of care	Video observation of neonatal care teams managing a resuscitation during a caesarean section	Structured observation of communication, team management and leadership	Compliance with Neonatal Resuscitation Program guidelines
Tschan, Semmer, Gautschi, et al.[95]	2006	To investigate the influence of human factors on team performance in medical emergency driven groups	Video observation of medical emergency teams (senior doctor, resident, nurse) managing a cardiac arrest in a high-fidelity patient simulator	Structured observation of directive leadership and structuring inquiry	Clinical performance assessed based on a time-based coding of observable technical acts

Tschan, Semmer, Gurtner, et al.[96]	2009	To investigate the influence of communication on diagnostic accuracy in ambiguous situations	Video observation of groups of physicians diagnosing a difficult patient with an anaphylactic shock in a high-fidelity patient simulator	Structured observation of the diagnostic information that have been considered, explicit reasoning and talking to the room	Accuracy of diagnosis
Westli, Johnsen, Eid, et al.[97]	2010	To investigate whether demonstrated teamwork skills and behaviour indicating shared mental models would be associated with improved medical management	Video observation of trauma teams (surgeons, anaesthesiologists, nurses, radiographers) in a high-fidelity patient simulator	Assessment of non-technical skills using a behaviourally anchored rating scale (ANTS and ATOM scoring system)	Checklist based expert rating
Wiegmann, El Bardissi, Dearani, et al.[98]	2007	To investigate surgical errors and their relationship to surgical flow disruptions to understand better the effect of these disruptions on surgical errors and patient safety	Live observation of surgical teams conducting cardiac surgery operations	Structured observation of teamwork and communication failures	Structured observation of surgical errors during the operation
Williams, Lasky, Dannemiller, et al.[99]	2010	To describe relationships between teamwork behaviours and errors during neonatal resuscitation	Video observation of intensive care teams managing neonatal resuscitations	Structured observation of teamwork behaviour (vigilance, workload management, information sharing, inquiry, assertion)	Structured observation of errors (non-compliance with guidelines)
Wright, Phillips-Bute, Petrusa, et al.[100]	2009	To test if observer ratings of team skills will correlate with objective measures of clinical performance	Video observation of teams consisting of medical students performing low-fidelity classroom based patient assessment and high-fidelity simulation emergent care.	Observation using a behaviourally anchored rating scale for teamwork skills (assertiveness, decision-making, situation assessment, leadership, communication)	Checklist based expert rating
Yamada, Fuerch, Halamek[101]	2016	To investigate the effect of standardized communication techniques on errors during resuscitation	Video observation of teams (Neonatologists, neonatal nurse practitioners, neonatology fellows) managing neonatal resuscitation	Structured observation of standardised communication	Error rate Time to initiate positive pressure ventilation Time to chest compression

Table 2. Studies, effect sizes and moderator variables included in the meta-analytic database

Authors	Year	Study goal	Setting	No. of teams	Professional composition	Team familiarity	Average team size	Task type	Patient realism	Performance measure
Amacher, Schumacher, Legeret, et al.[77]	2017	.11	Emergency medicine	72	Uniprofessional	Experimental	3	Non-routine	Simulated	Process
Brogaard, Kierkegaard, Hvidmand, et al.[60]	2018	.43	Obstetrics	99	Interprofessional	Real	5	Non-routine	Real	Process
Burtscher, Kolbe, Wacker, et al.[78]	2011	-.27	Anaesthesia	31	Interprofessional	Experimental	2	Routine	Simulated	Process
Burtscher, Manser, Kolbe, et al.[79]	2011	.19	Anaesthesia	15	Interprofessional	Experimental	2	Routine & non-routine	Simulated	Process
Burtscher, Wacker, Grote, et al.[80]	2010	.07	Anaesthesia	22	Interprofessional	Real	3	Non-routine	Real	Process
Carlson, Min, Bridges[9][b]	2009	.83	Emergency medicine	44	Uniprofessional	Experimental	2.6	Non-routine	Simulated	Process
Catchpole, Giddings, Wilkinson, et al.[58]	2007	.45†	Surgery	24	Interprofessional	Real	9	Non-routine	Real	Process
	2007	.29†	Surgery	18	Interprofessional	Real	5	Routine	Real	Process
Catchpole, Mishra, Handa, et al.[59]	2008	.36†	Surgery	26	Interprofessional	Real		Routine	Real	Process
	2008	.09†	Surgery	22	Interprofessional	Real		Routine	Real	Process
Cooper, Wakelam[81]	1999	.50	General care	20	Interprofessional	Real	4	Routine	Real	Process
Davenport, Henderson, Mosca, et al.[82]	2007	.17	Surgery	52	Interprofessional	Real		Routine	Real	Outcome
El Bardissi, Wiegmann, Henrickson, et al.[83]	2008	.67	Surgery	31	Interprofessional	Real	7	Routine	Real	Process
Gillespie, Chaboyer, Fairweather[84]	2012	.23	Surgery	160	Interprofessional	Real	6	Routine	Real	Process
Kolbe, Burtscher, Wacker, et al.[85]	2012	.33	Anaesthesia	31	Interprofessional	Real	2	Non-routine	Simulated	Process
Kuenzle, Zala-Mezo, Wacker, et al.[86]	2009	.56	Anaesthesia	12	Interprofessional	Real	2	Routine	Simulated	Process
Manojilovich, Antonakos, David, et al.[87]	2009	.11	Intensive care	25	Uniprofessional	Real	36	Routine	Real	Outcome

Manser, Bogdanovic, Clack, et al.[61]	2015	.39	Surgery	19	Interprofessional	Experi-mental	5	Routine	Simulated	Process
Marsch, Müller, Marquardt, et al.[88]	2004	.23	Intensive care	16	Interprofessional	Experi-mental	3	Non-routine	Simulated	Process
Mazzocco, Petitti, Fong, et al.[89]	2009	.11	Surgery	293	Interprofessional	Real	6	Routine	Real	Outcome
Mishra, Catchpole, Dale, et al.[90]	2008	.05	Surgery	26	Interprofessional	Real	6	Routine	Real	Process
Schmutz, Hoffmann, Heimberg, et al.[91]	2015	.12	Emergency medicine	68	Interprofessional	Real	6	Non-routine	Simulated	Process
Siassakos, Bristowe, Draycott, et al.[92]	2012	.66	Obstetrics	19	Interprofessional	Real	6	Non-routine	Simulated	Process
Siassakos, Fox, Crofts, et al.[93]	2011	.55	Emergency medicine/ obstetrics	24	Interprofessional	Experi-mental	6	Non-routine	Simulated	Process
Thomas, Sexton, Lasky, et al.[94]	2006	.23	Neonatal care	132	Interprofessional	Real	5	Non-routine	Real	Process
Tschan, Semmer, Gautschi, et al.[95]	2006	.23	Emergency medicine	21	Interprofessional	Experi-mental	5	Non-routine	Simulated	Process
Tschan, Semmer, Gurtner, et al.[96]	2009	.37	Emergency medicine	20	Uniprofessional	Experi-mental	2.65	Non-routine	Simulated	Outcome
Westli, Johnsen, Eid, et al.[97]	2010	.18	Emergency medicine	27	Interprofessional	Real	5.1	Non-routine	Simulated	Process
Wiegmann, El Bardissi, Dearani, et al.[98]	2007	.56	Surgery	31	Interprofessional	Real		Routine	Real	Process
Williams, Lasky, Dannemiller, et al.[99]	2010	.18	Neonatal care	12	Interprofessional	Real	5	Non-routine	Real	Process
Wright, Phillips-Bute, Petrusa, et al.[100]	2009	.81	General care	9	Uniprofessional	Experi-mental	4	Non-routine	Simulated	Process
Yamada, Fuerch, Halamek[101]	2016	.11	Emergency medicine	13	Interprofessional	Experi-mental	3	Non-routine	Simulated	Process

[a] Effect sizes (*r*) with an † represent an average for a single sample and a single outcome and have been combined for this meta-analysis.

[b] Carlson, Min & Bridges has been identified as an outlier and therefore excluded from the analysis

Table 3. Meta-Analytic relationships between teamwork and clinical performance

	N	k	r	95% CI	80% CR	Q	I^2
Overall relationship	1,390	31	.28	[.20 ; .35]	[.09 ; .45]	53.7	46.0
Team characteristics							
Professional composition							
Interprofessional	1,264	27	.28	[.20 ; .36]	[.09 ; .46]	47.1*	48.2
Uniprofessional	126	4	.28	[-.01 ; .52]	[-.04 ; .54]	6.5	47.1
Team familiarity							
Experimental team	240	10	.25	[.05 ; .43]	[-.05 ; .51]	17.2*	47.2
Real team	1,150	21	.29	[.20 ; .37]	[.12 ; .45]	36.2*	45.7
Team size[a]							
Task characteristics							
Task type							
Routine task	766	14	.27	[.12 ; .40]	[-.01 ; .50]	30.9*	65.0
Non-routine task	609	16	.29	[.20 ; .39]	[.16 ; .42]	20.5	24.6
Methodological factors							
Patient realism							
Real patient	993	16	.28	[.18 ; .38]	[.10 ; .45]	28.7*	49.3
Simulated patient	397	15	.28	[.13 ; .41]	[.02 ; .50]	25.0*	44.6
Performance measures							
Outcome performance	390	4	.13	[.03 ; .23]	[.06 ; .19]	1.3	0.0
Process performance	1,000	27	.30	[.21 ; .39]	[.10 ; .49]	45.6*	45.6

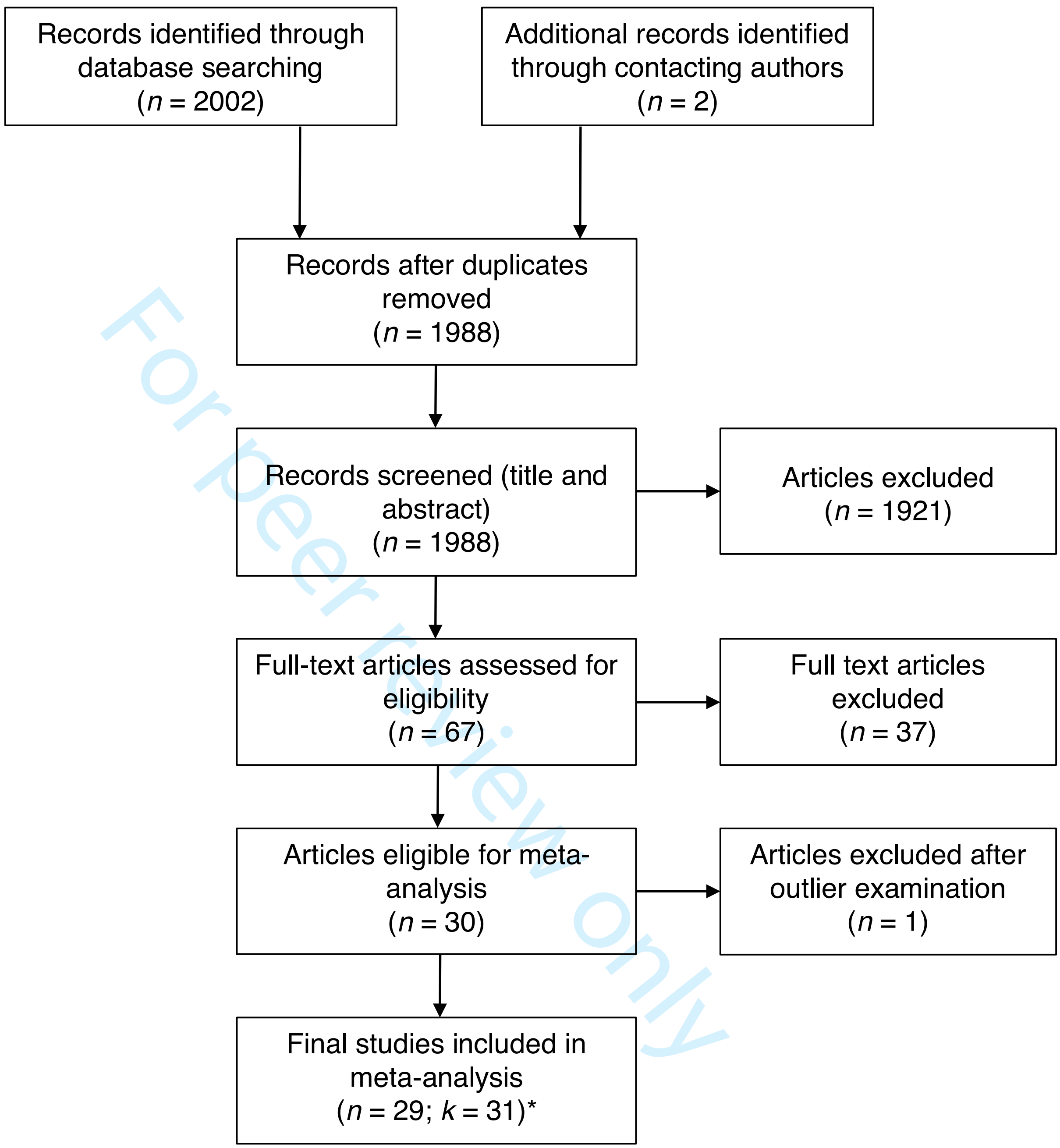
Note. k = number of studies; N = cumulative sample size (number of teams); r = sample-size weighted correlation; CI = confidence interval; CR = credibility interval; Q = test statistic for residual heterogeneity of the models; I^2 = % of total variability in the effect size estimates due to heterogeneity among true effects (vs. sampling error)

[a] Team size was entered as a continuous variable, therefore, no subgroup analyses exist

LEGENDS TO FIGURES

Figure 1 Systematic literature search

Figure 2 Relationship between teamwork processes and performance


Records identified through database searching (n = 2002)
Additional records identified through contacting authors (n = 2)
Records after duplicates removed (n = 1988)
Records screened (title and abstract) (n = 1988)
Articles excluded (n = 1921)
Full-text articles assessed for eligibility (n = 67)
Full text articles excluded (n = 37)
Articles eligible for meta-analysis (n = 30)
Articles excluded after outlier examination (n = 1)
Final studies included in meta-analysis (n = 29; k = 31)*

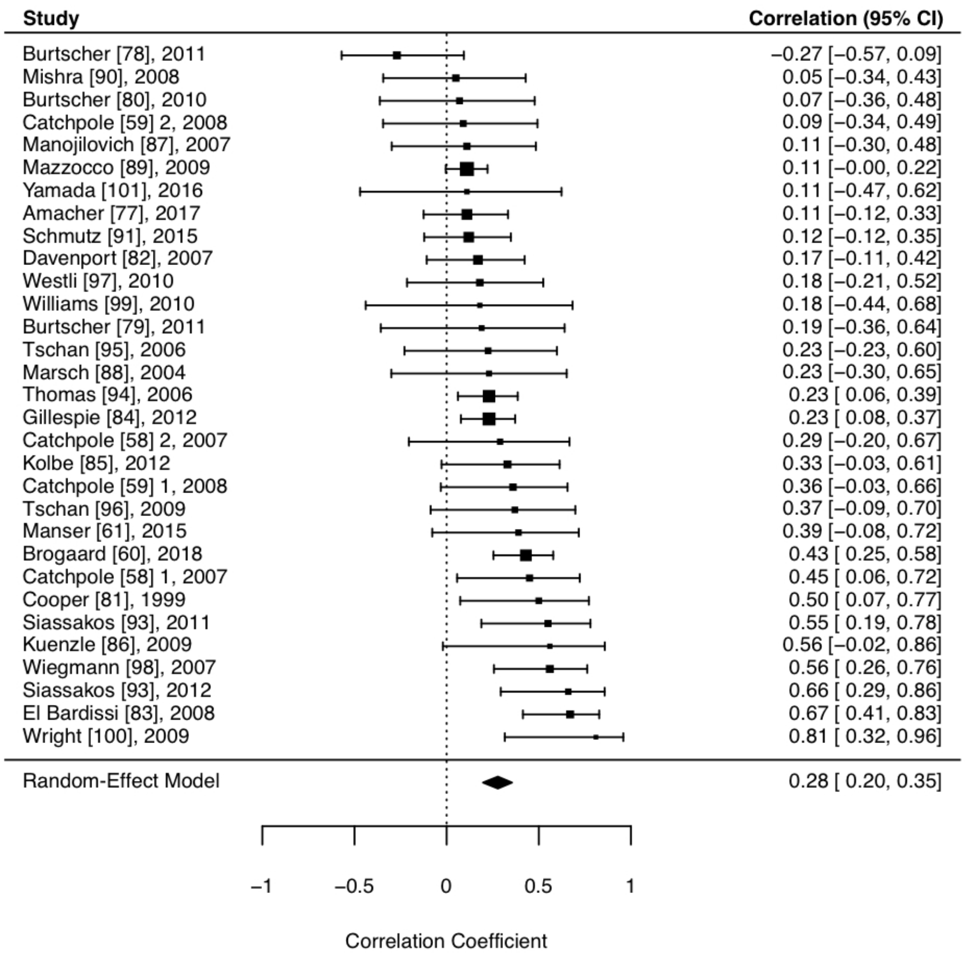


Figure 2. Relationship between teamwork processes and performance.

SUPPLEMENTARY FILE

Article: **How effective is teamwork really? The relationship between teamwork and performance in healthcare teams: A systematic review and meta-analysis**

Jan B. Schmutz, PhD, Laurenz L. Meier, PhD, Tanja Manser, PhD

Search terms used for PubMed search

(Teamwork[All Fields]) OR (team[All Fields] AND coordination[All Fields]) OR (team[All Fields] AND "decision making"[All Fields]) OR ((team[All Fields]) AND (communication[MeSH Terms]) OR (communication[All Fields])) OR (team[All Fields] AND leadership[All Fields]) AND (patient safety[MeSH Terms])

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4-8
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4-5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	n/a
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	9-10
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	9
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	9 and supplemental material
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	9-10
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	10
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	9-12
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	20
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	13-19 / 23

PRISMA 2009 Checklist

Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	20-23

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	20,26
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	22-23
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	21
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	18-19
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	18-19, 20
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	13-19
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	23
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	23
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	N/A
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	24-27
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	26-27
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	27
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	28

PRISMA 2009 Checklist

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

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Page 2 of 2

BMJ Open

How effective is teamwork really? The relationship between teamwork and performance in healthcare teams: A systematic review and meta-analysis

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Primary Subject Heading:	Communication
Secondary Subject Heading:	Communication
Keywords:	teamwork, non-technical skills, communication, meta-analysis, teams

How effective is teamwork really? The relationship between teamwork and performance in healthcare teams: A systematic review and meta-analysis

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Word count: 4770

Keywords: teamwork, non-technical skills, communication, teams, meta-analysis

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ABSTRACT

Objectives To investigate the relationship between teamwork and clinical performance and potential moderating variables of this relationship.

Design Systematic review and meta-analysis.

Data Source PubMed was searched in June 2018 without a limit on the date of publication. Additional literature was selected through a manual backward search of relevant reviews, manual backward and forward search of studies included in the meta-analysis and contacting of selected authors via e-mail.

Eligibility Criteria Studies were included if they reported a relationship between a teamwork process (e.g. coordination, non-technical skills) and a performance measure (e.g. checklist based expert rating, errors) in an acute care setting.

Data Extraction and Synthesis Moderator variables (i.e. professional composition, team familiarity, average team size, task type, patient realism and type of performance measure) were coded and random-effect models were estimated. Two investigators independently extracted information on study characteristics in accordance with PRISMA guidelines.

Results The review identified 2002 articles of which 31 were included in the meta-analysis comprising 1390 teams. The sample-sized weighted mean correlation was r = .28 (corresponding to an odds ratio of 2.8), indicating that teamwork is positively related to performance. The test of moderators was not significant, suggesting that the examined factors did not influence the average effect of teamwork on performance.

Conclusion Teamwork has a medium-sized effect on performance. The analysis of moderators illustrated that teamwork relates to performance regardless of characteristics of the team or task.

Therefore, healthcare organizations should recognize the value of teamwork and emphasize approaches that maintain and improve teamwork for the benefit of their patients.

ARTICLE SUMMARY

Strengths and limitations of this study

- This systematic review evaluates available studies investigating the effectiveness of teamwork processes.
- 31 studies have been included resulting in a substantial sample size of 1390 teams.
- The sample size of the primary studies included is usually low.
- For some subgroup analysis, the number of studies included was small.

INTRODUCTION

May it be an emergency team in the trauma room, paramedics treating patients after an accident or a surgical team in the operating room, teams are ubiquitous in healthcare and must work across professional, disciplinary and sectorial boundaries. Although the clinical expertise of individual team members is important to ensure high performance, teams must be capable of applying and combining the unique expertise of team members to maintain safety and optimal performance. In order for a team to be effective individual team members need to collaborate and engage in teamwork. Today, experts agree that effective teamwork anchors safe and effective care at various levels of the healthcare systems[1-4] leading to a relatively recent shift towards team research and training.[5-7]

Healthcare is an evidence-based field and therefore administrators and providers are seeking evidence in the literature concerning the impact of teamwork on performance outcomes like patient mortality, morbidity, infection rates or adherence to clinical treatment guidelines. Having a closer look at the literature investigating healthcare teams we find mixed and sometimes even contradicting results about the relationship between teamwork and clinical performance.[8] Some studies find a large effect of teamwork on performance outcomes (e.g. Carlson et al.[9]) while others report small or no relationships.[10,11] This inconsistency arises due to several reasons. First, the conceptual and empirical literature examining teamwork is fragmented and research examining teamwork effectiveness is spread across disciplines including medicine, psychology and organization science. Therefore, researchers and practitioners often lack a common conceptual foundation for investigating teams and teamwork in healthcare. Second, research studies on teamwork in healthcare usually exhibit small sample sizes because of the challenges of recruiting actual professional teams and carefully balancing research with patient

care priorities. Small sample sizes, however, increase the likelihood of reporting results that fail to represent true effect. Third, studies investigating healthcare teams often ignore important context variables of teams (e.g. team composition and size, task characteristics, team environment) that likely influence the effect that teamwork has on clinical performance.[12,13]

These inconsistencies in the teamwork literature may lead to confusion about the importance of teamwork in healthcare, thus giving voice to critics who hinder efforts to improve teamwork. We aim to address these problems with a meta-analytical study investigating the performance implications of teamwork. A meta-analytical approach moves beyond existing reviews on teamwork in healthcare[8,14-17] and quantitatively tests if the widely advocated positive effect of teamwork on performance holds true. In addition, this approach allows us to investigate context variables as moderators that may influence the effect of teamwork on performance, meaning that this effect might be stronger or weaker under certain conditions. Previous meta-analyses[18,19] focused mainly on the effectiveness of team trainings but not on the effect of teamwork itself. This meta-analysis will generate quantitative evidence to inform the relevance of future interventions, regulations and policies targeting teamwork in healthcare organizations.

In the following we will first establish an operational definition of teamwork, elaborate on relevant contextual factors, and present our respective meta-analytic results and their interpretation.

Teams, teamwork and team performance

In order to clearly understand the impact of teamwork on performance it is necessary to provide a brief introduction to teams, teamwork and team performance. We define teams as identifiable social work units consisting of two or more people with several unique

characteristics. These characteristics include *a)* dynamic social interaction with meaningful interdependencies; *b)* shared and valued goals, *c)* a discrete lifespan, *e)* distributed expertise and *f)* clearly assigned roles and responsibilities.[20,21] Based on this definition it becomes clear that teams must dynamically share information and resources amongst members and coordinate their activities in order to fulfil a certain task—in other words teams need to engage in *teamwork.*

Teamwork as a term is widely used and often difficult to grasp. However, we absolutely require a clear definition of teamwork especially for team trainings that target specific behaviours. *Teamwork* is a process that describes interactions among team members who combine collective resources to resolve task demands (e.g. giving clear orders).[22,23] Teamwork or team processes can be differentiated from *taskwork*. *Taskwork* denotes a team's individual interaction with tasks, tools, machines and systems.[23] *Taskwork* is independent of other team members and is often described as *what* a team is doing whereas *teamwork* is *how* the members of a team are doing something with each other.[24] Therefore, *team performance* represents the accumulation of teamwork and taskwork (i.e. what the team actually does).[25]

Team performance is often described in terms of inputs, processes and outputs (IPO).[22,26-28] *Outputs* like quality of care, errors or performance are influenced by team related *processes* (i.e. teamwork) like communication, coordination or decision making. Furthermore, these processes are influenced by various *inputs* like team members' experience, task complexity, time pressure and more. The IPO framework emphasizes the critical role of team processes as the mechanism by which team members combine their resources and abilities, shaped by the context, to resolve team task demands. It has been the basis of other more advanced models[27-29] but has also been criticized because of its simplicity.[30] However, it is still the most popular

framework to date and helps to systematize the mechanisms that predict team performance and represents the basis for the selection of the studies included in our meta-analysis.

Contextual factors of teamwork effectiveness

Based on a large body of team research from various domains, we hypothesize that several contextual and methodological factors might moderate the effectiveness of teamwork, indicating that teamwork is more important under certain conditions.[31,32] Therefore, we investigate several factors: (a) team characteristics (i.e. professional composition, team familiarity, team size); (b) task type (i.e. routine vs. non-routine tasks); (c) two methodological factors related to patient realism (i.e. simulated vs. real) and the type of performance measures used (i.e. process vs. outcome performance). In the following we discuss these potentially moderating factors and the proposed effects on teamwork.

Professional composition. We distinguished between interprofessional and uniprofessional teams. Interprofessional teams consist of members from various professions that must work together in a coordinated fashion.[33] Diverse educational paths in interprofessional teams may shape respective values, beliefs, attitudes and behaviours.[34] As a result team members with different backgrounds might perceive and interpret the environment differently and have a different understanding of how to work together. Therefore, we assume that explicit teamwork is especially important in interprofessional teams compared to uniprofessional teams.

Team familiarity. If team members have worked together, they are familiar with their individual working styles; and roles and responsibilities are usually clear. If a team works together for the first time, this potential lack of familiarity and clarity might make teamwork even more important. Therefore, we differentiate between *real teams* that also work together in

their everyday clinical practice and *experiential teams* that only came together for study purposes.

Team size. Another factor that may moderate the relationship between teamwork and performance is team size. Since larger teams exhibit more linkages among members than smaller teams, they also face greater coordination challenges. Also, with increasing size teams have greater difficulty developing and maintaining role structures and responsibilities. For these reasons, we expect the influence of teamwork on clinical performance to be stronger in larger teams as compared to smaller teams.

Task type. Routine situations are characterized by repetitive and unvarying actions (e.g. standard anaesthesia induction).[35] In contrast, non-routine situations exhibit more variation and uncertainty, requiring teams to be flexible and adaptive. Whereas team members mostly rely on pre-learned sequences during routine situations, during non-routine situations we assume that teamwork is more important in order for team members to resolve task demands.

Patient realism. Authors highlight the importance of using medical simulators in education.[36] Therefore, we investigate the realism used in a study (simulated vs. real patients) as a potential methodological factor that influences the relationship between teamwork and performance. Studies conducted with medical simulators might be more standardized and less influenced by confounding variables than studies conducted with real patients. Therefore, results from simulation studies might show stronger relationships between the two variables. Further, using a simulator could cause individuals and teams to act differently than in real settings, thereby distorting the results. However, in the last decade high-fidelity simulators have become increasingly realistic, suggesting that the results from simulation studies generalize to real environments. Including realism as a contextual factor in our analysis will reveal if the effects of

teamwork observed in simulation compare with real life settings. Better understanding would provide important insights about simulation use in teamwork studies.

Performance measures. As a second methodological factor, we expect that the type of performance measure used in a study influences the reported teamwork effectiveness. The literature usually differentiates between process- and outcome-related aspects of performance.[37,38] Process performance measures are action-related aspects and refer to adequate behaviour during procedures (e.g. adhering to guidelines), making them easier to assess. Outcome performance measures (e.g. infection rates after operations) follow team actions, with assessment occurring later than process measures. Outcome performance measures suffer from several factors: greater sensitivity to confounding variables (e.g. comorbidities), assessment challenges, and greater difficulty linking team processes to outcomes. Looking at the predictors of the survival of cardiac arrest patients illustrates the difference between the two types of performance measures. The main predictors for the survival (i.e. performance outcome) of a cardiac arrest patient are *"duration of the arrest"* and *"age of the patient less than 70"*.[39] Although a team delivers perfect basic life support (i.e. high process performance) the patient can still die (i.e. low outcome performance). Due to these methodological considerations, we expect that studies assessing process performance report a stronger relationship between teamwork and performance than studies assessing outcome performance.

METHODS

The study was conducted based on the recommendations of the PRISMA statement[40] as well as established guidelines in social sciences.[41,42] Through the combination of studies in the meta-analytical process, we will increase the statistical power and provide an accurate estimation of the true impact that teamwork has on performance.

Search strategy

We applied the following search strategy to select relevant papers: *a)* an electronic search of the data base PubMed (no limit was placed on the date of publication, last search 19th of June 2018) using the key words *teamwork*, *coordination*, *decision making*, *leadership* and *communication* in combination with *patient safety*, *clinical performance*, the final syntax for PubMed is available online (Supplementary File), b) a manual backwards search for all references cited by 8 systematic literature reviews that focus on teamwork or non-technical skills in various healthcare domains,[8,15,17,43-47] c) a manual backwards search for all references cited in studies we included in our meta-analysis, d) a manual forward search using Web of Science to identify studies that cite the studies we included in our meta-analysis, e) identification of relevant unpublished manuscripts via e-mail from authors currently investigating medical teams using specific mailing lists.

Inclusion criteria

Studies were included if a construct complied to the definition of teamwork processes outlined in the introduction (e.g. coordination, communication). In addition, studies needed to investigate the relationship between at least one teamwork process and a performance measure (e.g. patient outcome). When studies reported multiple estimates of the same relationship from

the same sample (e.g. between coordination and more than one indicator of performance), those correlations were examined separately only as appropriate for sub-analyses, but an average correlation was computed for all global meta-analyses of those relationships to maintain independence.[41] We excluded articles investigating long-term care since the coordination of care for chronically ill patients has to consider the unique team task interdependencies in this setting.[48] Also, teams working together over longer periods of time are more likely to develop emergent states (e.g. team cohesion) that influence how a specific team works together.[24] All articles included in this meta-analysis are listed in Table 1 and Table 2.

For the criterion level of analysis, we included only effect sizes at the team level and not on an individual level. Therefore, the performance measure had to be clearly linked to a team. This approach aligns with research that strongly recommends against mixing levels of analysis in meta-analytic integrations.[49,50]

Two reviewers independently screened titles and abstracts from articles yielded in the search. Afterwards full texts of all relevant articles were obtained and screened by the same two reviewers. Agreement was above 90%. Any disagreement in the selection process was resolved through consensus discussion.

Data extraction

With the help of a jointly developed coding scheme, studies were independently coded by one of the authors (JS) and another rater, both with a background in industrial psychology and human factors. 20% of the studies were rated by both coders. Intercoder agreement was above 90%. Any disagreement was resolved through discussion. The data extracted comprised details of the authors and publication as well as important study characteristics and statistical relationships between a teamwork variable and performance (Table 2).

Coding of team characteristics

The *professional composition* of teams was coded either as “Interprofessional” if a team consisted of members from different professions (e.g. nurses and physicians) or as “Uniprofessional” if the members of the teams were of the same profession. *Team size* was coded as the number of members (average number if team size varied) of the investigated teams. Team familiarity was coded either as “experimental” or “real”. “Real” indicates that the team members also worked together in their everyday clinical practice. “Experimental” means that the teams only worked together during the study.

Coding of task characteristics

Task type was coded either as “Routine task” or “Non-routine task”. We defined “Non-routine tasks” as unexpected events that require flexible behavior often under time-pressure (e.g. emergency situations). “Routine tasks” describe previously planned standard procedures (e.g. standard anesthesia induction, planned surgery).

Coding of methodological factors

Patient realism was either coded as “Real patient” or “Simulated patient”. “Simulated patient” included a patient simulator (manikin) whereas “Real patient” included real patients in clinical settings.

Clinical performance measures were coded either as “Outcome performance” or “Process performance”.[38,51] “Outcome performance” includes an outcome that is measured after the treatment process (e.g. infection rate, mortality). We focused only on patient-related outcomes and not on team outcomes (e.g. team satisfaction). "Process performance" describes the evaluation of the treatment process and describes how well the process was executed (e.g. adherence to guidelines through expert rating). Process performance measures are often based on official guidelines and extensive expert knowledge.[52] Thus, we assumed that process performance closely relates to patient outcomes.

Statistical Analysis

Different types of effect sizes (e.g. Odds ratio, F values, and r) have been reported in the original studies. We therefore converted the different effect sizes to a common metric, namely r using the formulas provided by Borenstein et al.[53] and Walker.[54] Moreover, some samples contained effect sizes of teamwork with two or more measures of performance. Because independence of the included effects sizes is required for a meta-analysis,[41,55] we used Fisher's z score to average the multiple correlations from the same sample. The correlations were weighted for sample size. However, in contrast to many meta-analyses in social sciences, the correlations were not adjusted for measurement reliability. This is because information about the measurement reliability could not be compared (Kappa vs. Cronbach Alpha) or were not available at all for the majority of studies. Therefore, we report uncorrected, sample-size weighted mean correlation, its 95% confidence interval (CI), and the 80% credibility interval (CR). The CI reflects the accuracy of a point estimate and can be used to examine the significance of the effect size estimates, whereas the CR refers to the deviation of these estimates and informs us about the existence of possible moderators.

Random-effects models were estimated based on two considerations.[56] First, we expected study heterogeneity to be high given the different study design characteristics such as *patient realism* ("Real patient" vs. "Simulated patient"), *task type* ("Routine task" vs. "Non-routine task"), and different forms of performance measures. Second, we aimed to provide an inference on the average effect in the entire population of studies from which the included studies are assumed to be a random selection of it. Therefore, random-effects models were estimated.[56] These models were calculated by the restricted maximum-likelihood estimator, an efficient and unbiased estimator.[57] Since we included only descriptive studies and no interventions we only included the sample size of the individual studies as a potential bias into the meta-analysis. To rule out a potential publication bias, we tested for funnel plot asymmetry using the random-effect version of the Egger test.[58] The results indicate that there is no asymmetry in the funnel plot ($z = 1.79$, $p = .074$), suggesting that there is no publication bias.

The estimation of meta-analytical models including the outlier analyses were performed with the package "metafor" from the programming language and statistical environment R.[57]

Patient and public involvement

Patients and public were not involved in this study.

RESULTS

The online search resulted in 2002 articles (Figure 1). Two studies were identified via contacting authors directly and have been presented at conferences in the past.[59,60] After duplicates were removed 1988 articles were screened using title and abstract. 67 articles were then selected for a full text review. Full text examination, forward and backward search of selected articles and relevant reviews resulted in 30 studies coming from 28 articles (Two publications presented two independent studies in one publication[61,62]). This led to a total of 32 studies coming from 30 articles. Following the recommendation by Viechtbauer and Cheung,

[63] we screened for outliers using studentized deleted residuals. One case (Carlson et al.,[9] r = .89, n = 44, studentized deleted residuals = 4.26) was identified as outlier and therefore excluded from further analyses, resulting in a final sample size of k = 31.

Table 1 provides a qualitative description of the selected articles including study objectives, the setting in which the studies were carried out and a description of the teamwork processes as well as the outcome measures that were assessed. If a specific tool for the assessment of a teamwork process or outcome measure was used this is indicated in the corresponding column. Observational studies were most prevalent. Teamwork processes were assessed using either behaviourally anchored rating scales (N=8) or structured observation (N=19) of specific teamwork behaviour. Structured observation—as we describe it—is defined as a purely descriptive assessment of certain behaviour usually using a predefined observation system (e.g. amount of speaking up behaviour). In contrast, behaviourally anchored rating scales consist of an evaluation of teamwork process behaviour by an expert. Only three studies used surveys to assess teamwork behaviours. The majority of the studies (N=27) assessed process performance using either a checklist-based expert rating or assessing a reaction time measure after the occurrence of a certain event (e.g. time until intervention). Only four studies assessed outcome performance measures. Measures included accuracy of diagnosis, postoperative complications and death, surgical morbidity and mortality, ventilator-associated pneumonia, bloodstream infections, pressure ulcers and acute physiology and chronic health evaluation score. Table 2 provides an overview of all variables included in the meta-analysis including the effect sizes and moderator variables.

Effect of teamwork and contextual factors

Table 3 and Figure 2 shows the relationship between teamwork and team performance. The sample-sized weighted mean correlation was .28 (95% CI: .20 to .35, $z = 6.55$, $p < .001$), indicating that teamwork is positively related to clinical performance. Results further indicated heterogeneous effect size distributions across the included samples ($Q = 53.73$, $p < .05$, $I^2 = 45.96$), signifying that the variability across the sample effect sizes was more than what would be expected from sampling error alone.

To test for moderator effects of the contextual factors, we conducted mixed-effects models including the mentioned moderators: *professional composition, team familiarity, team size, task type, patient realism* and *performance measures.*

The omnibus test of moderators was not significant ($F = 0.18$, $df_1 = 6$, $df_2 = 18$, $p > .20$), suggesting that the examined contextual factors did not influence the average effect of teamwork on clinical performance. To provide greater detail about the role of the contextual factors, we conducted separate analyses for the categorical contextual factors and report them in Table 3.

DISCUSSION

With this study, we aimed to provide evidence for the performance implications of teamwork in healthcare teams. By including various contextual factors, we investigated potential contingencies that these factors might have on the relationship between teamwork and clinical performance. The analysis of 1390 teams from 31 different studies showed that teamwork has a medium sized effect (r=.28; [64,65]) on clinical performance across various care settings. Our study is the first to investigate this relationship quantitatively with a meta-analytical procedure. This finding aligns with and advances previous work that explored this relationship in a qualitative way.[8,15,17,43-47]

At first glance a correlation of r=.28 might not seem very high. However, we would like to highlight that r=.28 is considered a medium sized effect[64,65] and should not be underestimated. To better illustrate what this effect means we transformed the correlation into an odds ratio (OR) of 2.8.[53] Of course, this transformation simplifies the correlation because teamwork and often the outcome measures are not simple dichotomous variables that can be divided into an intervention and control group. However, this transformation illustrates that teams who engage in teamwork processes are 2.8 times more likely to achieve high performance than teams who are not. Looking at the performance measures in our study we see that they either describe patient outcomes (e.g. mortality, morbidity) or are closely related to patient outcomes (e.g. adherence to treatment guidelines). Thus, we consider teamwork a performance-relevant process that needs to be promoted through training and implementation into treatment guidelines and policies.

The included studies used a variety of different measures for clinical performance. This variability resulted from the different clinical contexts in which the studies were carried out.

There is no universal measure for clinical performance because the outcome is in most cases context specific. In surgery, common performance measures are surgical complications, mortality or morbidity.[66] In anaesthesia, studies often use expert ratings based on checklists to assess the provision of anaesthesia. Expert ratings are also the common form of performance assessment in simulator settings where patient outcomes like morbidity or mortality cannot be measured. Future studies need to be aware that clinical performance measures depend on the clinical context and that the development of valid performance measures requires considerable effort and scientific rigor. Guidelines on how to develop performance assessment tools for specific clinical scenarios exist and need to be accounted for.[52,67,68] Furthermore, depending on the clinical setting researchers need to evaluate what specific clinical performance measures are suitable and if and how they can be linked to team processes in a meaningful way.

The analysis of moderators illustrates that teamwork is related with performance under a variety of conditions. Our results suggest that teams in different contexts characterised by different team constellations, team size and levels of acuity of care all benefit from teamwork. Therefore, clinicians and educators from all fields should strive to maintain or increase effective teamwork. In recent years, there has been an upsurge in crisis resource management (CRM).[19] These trainings focus on team management and implement various teamwork principles during crisis situations (e.g. emergencies).[69] Our results suggest that team trainings should not only focus on non-routine situations like emergencies but also on routine situations (e.g. routine anaesthesia induction, routine surgery) because based on our data teamwork is equally important in such situations.

A closer look at methodological factors of the included studies revealed that the observed relationship between teamwork and performance in simulation settings does not differ from

relationships observed in real settings. Therefore, we conclude that teamwork studies conducted in simulation settings generalize to real life settings in acute care. Further, the analysis of different performance measures reveals a trend towards process performance measures being more strongly related with teamwork than outcome performance measures. A possible explanation of this finding relates to the difficulty of investigating outcome performance measures in a manner isolated from other variables. Nevertheless, we still found a significant relationship between teamwork and objective patient outcomes (e.g. postoperative complications, bloodstream infections) despite the methodological challenges of measuring outcome performance and the small number of studies using outcome performance (k = 4).

Our results are in line with previous meta-analyses investigating the effectiveness of team training in healthcare.[18,19] Similar to our results, Hughes et al. highlighted the effectiveness of team trainings under a variety of conditions—irrespective of team composition,[18] simulator fidelity or patient acuity of the trainee's unit as well as other factors.

We were unable to find a moderation of task type in our study, potentially explained by task interdependence, which reflects the degree to which team members depend on one another for their effort, information, and resources.[70] A meta-analysis including teams from multiple industries (e.g. project teams, management teams) found that task interdependence moderates the relationship between teamwork and performance, demonstrating the importance of teamwork for highly interdependent team tasks.[71] Most studies included in our analysis focused on rather short and intense patient care episodes (e.g. a surgery, a resuscitation task) with high task interdependence, which may explain the high relevance of teamwork for all these teams.

Limitations and future directions

Despite greater attention to healthcare team research and team training over the last decade, we were only able to identify 32 studies (31 included in the meta-analysis). Of note, over two-thirds of the studies in our analysis emerged in the last 10 years, reflecting the increasing interest in the topic. The rather small number of studies might relate to the difficulties in quantifying teamwork, the considerable theoretical and methodological knowledge required, and the challenges of capturing relevant outcome measures. Also, besides the manual searches of selected articles and reviews and contacting authors in the field we did only search the data base PubMed. PubMed is the most common database to access papers that potentially investigate medical teams and includes approximately 30’000 journals from the field of medicine, psychology and management. We are confident that through the additional inclusion of relevant reviews and forward and backwards search, our results represent an accurate representation of what can be found in the literature.

Future research should build on recent theoretical and applied work[24,26,28,72] about teamwork and use this current meta-analysis as a signpost for future investigations. In order to move our field forward, we must use existing conceptual frameworks[22,24,26] and establish standards for investigating teams and teamwork. This can often only be achieved with interdisciplinary research teams including experts from the medical fields but equally important from health professions education, psychology or communication studies.

Another limitation relates to the unbalanced analysis of subgroups. For example, we only identified four studies that used outcome performance variables compared to 27 using process performance measures. Uneven groups may reduce the power to detect significant differences.

Therefore, we encourage future studies to include outcome performance measures despite the effort required.

Finally, more factors may influence the relationship between teamwork and performance that we were unable to extract from the studies. While we tested for the effects of team familiarity by comparing experimental teams and real teams, this does not fully capture team member familiarity. The extent to which team members actually worked together during prior clinical practice might predict of how effectively they perform together. However, even two people working in the same ward might actually not have interacted much during patient care depending on the setting. Also team climate on a ward or in a hospital may be an important predictor of how well teams work together, especially related to sharing information or speaking up within the team.[73,74]

Finally, the clinical context might play a role in how team members collaborate. In different disciplines, departments or healthcare institutions different norms and routines exist on how to work together. Therefore, study results and recommendations about teamwork need to be interpreted in the light of the respective clinical context. There are empirical indications that a one-size-fits-all approach might not be suitable and team training efforts cannot ignore the clinical context, especially the routines and norms about collaboration.[75] We acknowledge that there might be other factors surrounding healthcare teams that might potentially influence teamwork and clinical performance. However, in this review we could only extract data that was reported in the primary studies. Since these were limited in the healthcare contexts studied, the results might not generalise to long-term care settings or mental health, for example. Future work needs to consider and also document a broader range of potentially influencing factors.

Conclusion

The current meta-analysis confirms that teamwork across various team compositions represents a powerful process to improve patient care. Good teamwork can be achieved by joint reflection about teamwork during clinical event debriefings[76,77] as well as team trainings[78] and system improvement. All healthcare organisations should recognise these findings and place continuous efforts into maintaining and improving teamwork for the benefit of their patients.

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Table 1. Descriptions of study objectives, settings and description of teamwork process and outcome measures

Authors	Year	Main study objectives	Participants and setting	Teamwork process measure	Outcome measure
Amacher, Schumacher, Legeret, et al.[79]	2017	To compare female and male rescuers in regard to cardiopulmonary resuscitation and leadership performance	Video observation of medical students managing cardiopulmonary resuscitation in a high-fidelity patient simulator	Structured observation of secure leadership statements within teams	Time until start chest compression Hands-on time within first 180 seconds
Brogaard, Kierkegaard, Hvidmand, et al.[59]	2018	To investigate the relationship between non-technical skills and clinical performance in obstetric teams	Video observation of obstetric teams (Obstetricians, obstetric nurse, anaesthesiologists) managing real-life emergencies (postpartum haemorrhage)	Assessment of non-technical skills using a behaviourally anchored rating scale (ATOP; Assessment of Obstetric Team Performance)	Checklist tool for clinical performance (TeamOBS-PPH)
Burtscher, Kolbe, Wacker, et al.[80]	2011	To investigate how team mental models and team monitoring behaviour interact to predict team performance in anaesthesia	Video observation of anaesthesia teams (residents, nurses) conducting a standard anaesthesia induction using a high-fidelity patient simulator	Structured observation of team monitoring behaviour	Checklist based expert rating
Burtscher, Manser, Kolbe, et al.[81]	2011	To investigate the relationship between adaptation of team coordination and clinical performance in response to a critical event	Video observation of anaesthesia teams (resident, nurse) conducting a standard anaesthesia induction including a critical event using a high-fidelity patient simulator	Structured observation of team coordination	Reaction time related to the critical event
Burtscher, Wacker, Grote, et al.[82]	2010	To examine the role of anaesthesia teams' adaptive coordination in managing changing situational demands	Video observation of anaesthesia teams (residents, nurses, students) conducting standard anaesthesia inductions with non-routine events	Structured observation of team coordination	Checklist based expert rating

Carlson, Min, Bridges[9]	2009	To explore the relationship between team behaviour and the delivery of an appropriate standard of care specific to the simulated case	Video observation of trainees participating in a simulated event involving the presentation of acute dyspnoea	Assessment of team behaviour using a behaviourally anchored rating scale (leadership and team behaviour measurement tool)	Checklist based expert rating
Catchpole, Giddings, Wilkinson, et al.[61]	2007	To investigate if effective teamwork can prevent the development of serious situations and provide evidence for improvements in training and systems	Live observation of surgical teams conducting paediatric cardiac and orthopaedic surgeries	Observation of non-technical skills using a behaviourally anchored rating scale (NOTECHS scoring system)	Assessment of minor problems, intraoperative performance and duration of surgery
Catchpole, Mishra, Handa, et al.[62]	2008	To analyse the effects of surgical, aesthetic, and nursing teamwork skills on technical outcomes	Observation of surgical teams conducting laparoscopic cholecystectomies and carotid endarterectomies	Observation of non-technical skills using a behaviourally anchored rating scale (NOTECHS scoring system)	Operating time and errors in surgical technique
Cooper, Wakelam[83]	1999	To examine the relationship between leadership behaviour, team dynamics and task performance	Video observation of emergency teams managing full cardiopulmonary arrests with a resuscitation attempt lasting longer than 3 minutes	Survey about leadership behaviour using the Leadership Behaviour Description Questionnaire	Checklist based expert rating
Davenport, Henderson, Mosca, et al.[84]	2007	To measure the impact of organizational climate safety factors on risk-adjusted surgical morbidity and mortality	Survey of staff on general and vascular surgery services	Survey about teamwork climate, level of communication and collaboration with surgeon	Surgical morbidity Surgical mortality
El Bardissi, Wiegmann, Henrickson, et al.[85]	2008	To identify patterns of teamwork failures that would benefit from intervention in the cardiac surgical setting	Live observation of surgical teams conducting cardiac surgery	Structured observation of teamwork failures that disrupted the flow of the operation	Surgical technical errors
Gillespie, Chaboyer, Fairweather[86]	2012	To investigate how various human factors variables, extend the expected length of an operation	Live observation of surgical teams across 10 specialties	Structured observation of numbers of communication failures	Deviation from expected length of operation

Kolbe, Burtscher, Wacker, et al.[87]	2012	To test the relationship between speaking up and technical team performance in anaesthesia.	Observation of 2-person (nurse, resident) ad hoc anaesthesia teams performing simulated inductions of general anaesthesia with minor nonroutine events	Structured observation of speaking up behaviour	Checklist based expert rating
Kuenzle, Zala-Mezo, Wacker, et al.[88]	2009	To investigate shared leadership patterns during anaesthesia induction and to show how they are linked to team performance	Observation of 2-person (nurse, resident) ad hoc anaesthesia teams performing simulated inductions of general anaesthesia with a nonroutine event (asystole)	Structured observation of leadership behaviour	Reaction time to nonroutine event
Manojilovich, Antonakos, David, et al.[89]	2009	To determine the relationships between patients' outcomes and nurses' perceptions of communication and characteristics of the practice environment.	A survey was conducted with nurses on various ICU wards	Survey about perception of nurse-physician communication using the ICU-nurse physician questionnaire	Ventilator-associated pneumonia Bloodstream infections Pressure ulcers Acute physiology and chronic health evaluation score
Manser, Bogdanovic, Clack, et al. [60]	2015	To investigate surgeons team management skills and its influence on performance	Live observation of surgical teams managing a simulated laparoscopic cholecystectomy	Structured observation of team management using the ComEd-E observation system	Checklist based expert rating
Marsch, Müller, Marquardt, et al.[90]	2004	To determine whether and how human factors affect the quality of cardiopulmonary resuscitation	Observation of healthcare worker (nurse, physician) managing a cardiac arrest due to ventricular fibrillation using a high-fidelity patient simulator	Structured observation of task distribution, information transfer and leadership behaviour within the team	Checklist based expert rating
Mazzocco, Petitti, Fong, et al.[91]	2009	To determine if patients of teams with good teamwork had better outcomes than those with poor teamwork	Live observation of surgical teams managing a variety of surgical procedures	Structured observation of information sharing, inquiry for relevant information and vigilance and awareness using a behaviourally anchored rating scale	Postoperative complications and death

Mishra, Catchpole, Dale, et al.[92]	2008	To report on the development and evaluation of a method for measuring operating-theatre teamwork quality	Live observation of surgical teams conducting laparoscopic cholecystectomy	Assessment of non-technical skills using a behaviourally anchored rating scale (NOTECHS scoring system)	Surgical technical errors assessed with the OCHRA-tool
Schmutz, Hoffmann, Heimberg, et al.[93]	2015	To investigate the moderating effect of task characteristics on the relationship between coordination and performance	Video observation of paediatric teams managing various paediatric emergencies using a high-fidelity patient simulator	Structured observation of closed loop communication, task distribution and provide information without request using the CoMeT-E observation system	Checklist based expert rating
Siassakos, Bristowe, Draycott, et al.[94]	2012	To investigate the relationship between patient satisfaction and communication	Video observation of teams (physicians, midwives) managing obstetric emergencies in secondary and tertiary maternity units	Structured observation of closed loop communication	Timely administration of magnesium sulphate
Siassakos, Fox, Crofts, et al.[95]	2011	To determine whether team performance in a simulated emergency is related to generic teamwork skills and behaviors	Video observation of healthcare professionals (physician, midwives) managing various emergencies using a high-fidelity patient simulator	Assessment of generic teamwork using a behaviourally anchored rating scale (teamwork analytical tool)	Clinical efficiency score
Thomas, Sexton, Lasky, et al.[96]	2006	To investigate the relationship of team behaviours during delivery room care and behaviours relate to the quality of care	Video observation of neonatal care teams managing a resuscitation during a caesarean section	Structured observation of communication, team management and leadership	Compliance with Neonatal Resuscitation Program guidelines
Tschan, Semmer, Gautschi, et al.[97]	2006	To investigate the influence of human factors on team performance in medical emergency driven groups	Video observation of medical emergency teams (senior doctor, resident, nurse) managing a cardiac arrest in a high-fidelity patient simulator	Structured observation of directive leadership and structuring inquiry	Clinical performance assessed based on a time-based coding of observable technical acts

Tschan, Semmer, Gurtner, et al.[98]	2009	To investigate the influence of communication on diagnostic accuracy in ambiguous situations	Video observation of groups of physicians diagnosing a difficult patient with an anaphylactic shock in a high-fidelity patient simulator	Structured observation of the diagnostic information that have been considered, explicit reasoning and talking to the room	Accuracy of diagnosis
Westli, Johnsen, Eid, et al.[99]	2010	To investigate whether demonstrated teamwork skills and behaviour indicating shared mental models would be associated with improved medical management	Video observation of trauma teams (surgeons, anaesthesiologists, nurses, radiographers) in a high-fidelity patient simulator	Assessment of non-technical skills using a behaviourally anchored rating scale (ANTS and ATOM scoring system)	Checklist based expert rating
Wiegmann, El Bardissi, Dearani, et al.[100]	2007	To investigate surgical errors and their relationship to surgical flow disruptions to understand better the effect of these disruptions on surgical errors and patient safety	Live observation of surgical teams conducting cardiac surgery operations	Structured observation of teamwork and communication failures	Structured observation of surgical errors during the operation
Williams, Lasky, Dannemiller, et al.[101]	2010	To describe relationships between teamwork behaviours and errors during neonatal resuscitation	Video observation of intensive care teams managing neonatal resuscitations	Structured observation of teamwork behaviour (vigilance, workload management, information sharing, inquiry, assertion)	Structured observation of errors (non-compliance with guidelines)
Wright, Phillips-Bute, Petrusa, et al.[102]	2009	To test if observer ratings of team skills will correlate with objective measures of clinical performance	Video observation of teams consisting of medical students performing low-fidelity classroom based patient assessment and high-fidelity simulation emergent care.	Observation using a behaviourally anchored rating scale for teamwork skills (assertiveness, decision-making, situation assessment, leadership, communication)	Checklist based expert rating
Yamada, Fuerch, Halamek[103]	2016	To investigate the effect of standardized communication techniques on errors during resuscitation	Video observation of teams (Neonatologists, neonatal nurse practitioners, neonatology fellows) managing neonatal resuscitation	Structured observation of standardised communication	Error rate Time to initiate positive pressure ventilation Time to chest compression

Table 2. Studies, effect sizes and moderator variables included in the meta-analytic database

Authors	Year	Study goal	Setting	No. of teams	Professional composition	Team familiarity	Average team size	Task type	Patient realism	Performance measure
Amacher, Schumacher, Legeret, et al.[79]	2017	.11	Emergency medicine	72	Uniprofessional	Experimental	3	Non-routine	Simulated	Process
Brogaard, Kierkegaard, Hvidmand, et al.[59]	2018	.43	Obstetrics	99	Interprofessional	Real	5	Non-routine	Real	Process
Burtscher, Kolbe, Wacker, et al.[80]	2011	-.27	Anaesthesia	31	Interprofessional	Experimental	2	Routine	Simulated	Process
Burtscher, Manser, Kolbe, et al.[81]	2011	.19	Anaesthesia	15	Interprofessional	Experimental	2	Routine & non-routine	Simulated	Process
Burtscher, Wacker, Grote, et al.[82]	2010	.07	Anaesthesia	22	Interprofessional	Real	3	Non-routine	Real	Process
Carlson, Min, Bridges[9][b]	2009	.83	Emergency medicine	44	Uniprofessional	Experimental	2.6	Non-routine	Simulated	Process
Catchpole, Giddings, Wilkinson, et al.[61]	2007	.45†	Surgery	24	Interprofessional	Real	9	Non-routine	Real	Process
	2007	.29†	Surgery	18	Interprofessional	Real	5	Routine	Real	Process
Catchpole, Mishra, Handa, et al.[62]	2008	.36†	Surgery	26	Interprofessional	Real		Routine	Real	Process
	2008	.09†	Surgery	22	Interprofessional	Real		Routine	Real	Process
Cooper, Wakelam[83]	1999	.50	General care	20	Interprofessional	Real	4	Routine	Real	Process
Davenport, Henderson, Mosca, et al.[84]	2007	.17	Surgery	52	Interprofessional	Real		Routine	Real	Outcome
El Bardissi, Wiegmann, Henrickson, et al.[85]	2008	.67	Surgery	31	Interprofessional	Real	7	Routine	Real	Process
Gillespie, Chaboyer, Fairweather[86]	2012	.23	Surgery	160	Interprofessional	Real	6	Routine	Real	Process
Kolbe, Burtscher, Wacker, et al.[87]	2012	.33	Anaesthesia	31	Interprofessional	Real	2	Non-routine	Simulated	Process
Kuenzle, Zala-Mezo, Wacker, et al.[88]	2009	.56	Anaesthesia	12	Interprofessional	Real	2	Routine	Simulated	Process
Manojilovich, Antonakos, David, et al.[89]	2009	.11	Intensive care	25	Uniprofessional	Real	36	Routine	Real	Outcome

Manser, Bogdanovic, Clack, et al.[60]	2015	.39	Surgery	19	Interprofessional	Experi-mental	5	Routine	Simulated	Process
Marsch, Müller, Marquardt, et al.[90]	2004	.23	Intensive care	16	Interprofessional	Experi-mental	3	Non-routine	Simulated	Process
Mazzocco, Petitti, Fong, et al.[91]	2009	.11	Surgery	293	Interprofessional	Real	6	Routine	Real	Outcome
Mishra, Catchpole, Dale, et al.[92]	2008	.05	Surgery	26	Interprofessional	Real	6	Routine	Real	Process
Schmutz, Hoffmann, Heimberg, et al.[93]	2015	.12	Emergency medicine	68	Interprofessional	Real	6	Non-routine	Simulated	Process
Siassakos, Bristowe, Draycott, et al.[94]	2012	.66	Obstetrics	19	Interprofessional	Real	6	Non-routine	Simulated	Process
Siassakos, Fox, Crofts, et al.[95]	2011	.55	Emergency medicine/ obstetrics	24	Interprofessional	Experi-mental	6	Non-routine	Simulated	Process
Thomas, Sexton, Lasky, et al.[96]	2006	.23	Neonatal care	132	Interprofessional	Real	5	Non-routine	Real	Process
Tschan, Semmer, Gautschi, et al.[97]	2006	.23	Emergency medicine	21	Interprofessional	Experi-mental	5	Non-routine	Simulated	Process
Tschan, Semmer, Gurtner, et al.[98]	2009	.37	Emergency medicine	20	Uniprofessional	Experi-mental	2.65	Non-routine	Simulated	Outcome
Westli, Johnsen, Eid, et al.[99]	2010	.18	Emergency medicine	27	Interprofessional	Real	5.1	Non-routine	Simulated	Process
Wiegmann, El Bardissi, Dearani, et al.[100]	2007	.56	Surgery	31	Interprofessional	Real		Routine	Real	Process
Williams, Lasky, Dannemiller, et al.[101]	2010	.18	Neonatal care	12	Interprofessional	Real	5	Non-routine	Real	Process
Wright, Phillips-Bute, Petrusa, et al.[102]	2009	.81	General care	9	Uniprofessional	Experi-mental	4	Non-routine	Simulated	Process
Yamada, Fuerch, Halamek[103]	2016	.11	Emergency medicine	13	Interprofessional	Experi-mental	3	Non-routine	Simulated	Process

[a] Effect sizes (*r*) with an † represent an average for a single sample and a single outcome and have been combined for this meta-analysis.

[b] Carlson, Min & Bridges has been identified as an outlier and therefore excluded from the analysis

Table 3. Meta-Analytic relationships between teamwork and clinical performance

	N	k	r	95% CI	80% CR	Q	I^2
Overall relationship	1,390	31	.28*	[.20 ; .35]	[.09 ; .45]	53.7*	46.0
Team characteristics							
Professional composition							
Interprofessional	1,264	27	.28*	[.20 ; .36]	[.09 ; .46]	47.1*	48.2
Uniprofessional	126	4	.28	[-.01 ; .52]	[-.04 ; .54]	6.5	47.1
Team familiarity							
Experimental team	240	10	.25*	[.05 ; .43]	[-.05 ; .51]	17.2*	47.2
Real team	1,150	21	.29*	[.20 ; .37]	[.12 ; .45]	36.2*	45.7
Team size[a]							
Task characteristics							
Task type							
Routine task	766	14	.27*	[.12 ; .40]	[-.01 ; .50]	30.9*	65.0
Non-routine task	609	16	.29*	[.20 ; .39]	[.16 ; .42]	20.5	24.6
Methodological factors							
Patient realism							
Real patient	993	16	.28*	[.18 ; .38]	[.10 ; .45]	28.7*	49.3
Simulated patient	397	15	.28*	[.13 ; .41]	[.02 ; .50]	25.0*	44.6
Performance measures							
Outcome performance	390	4	.13*	[.03 ; .23]	[.06 ; .19]	1.3	0.0
Process performance	1,000	27	.30*	[.21 ; .39]	[.10 ; .49]	45.6*	45.6

Note. *k* = number of studies; *N* = cumulative sample size (number of teams); *r* = sample-size weighted correlation; CI = confidence interval; CR = credibility interval; *Q* = test statistic for residual heterogeneity of the models; I^2 = % of total variability in the effect size estimates due to heterogeneity among true effects (vs. sampling error)

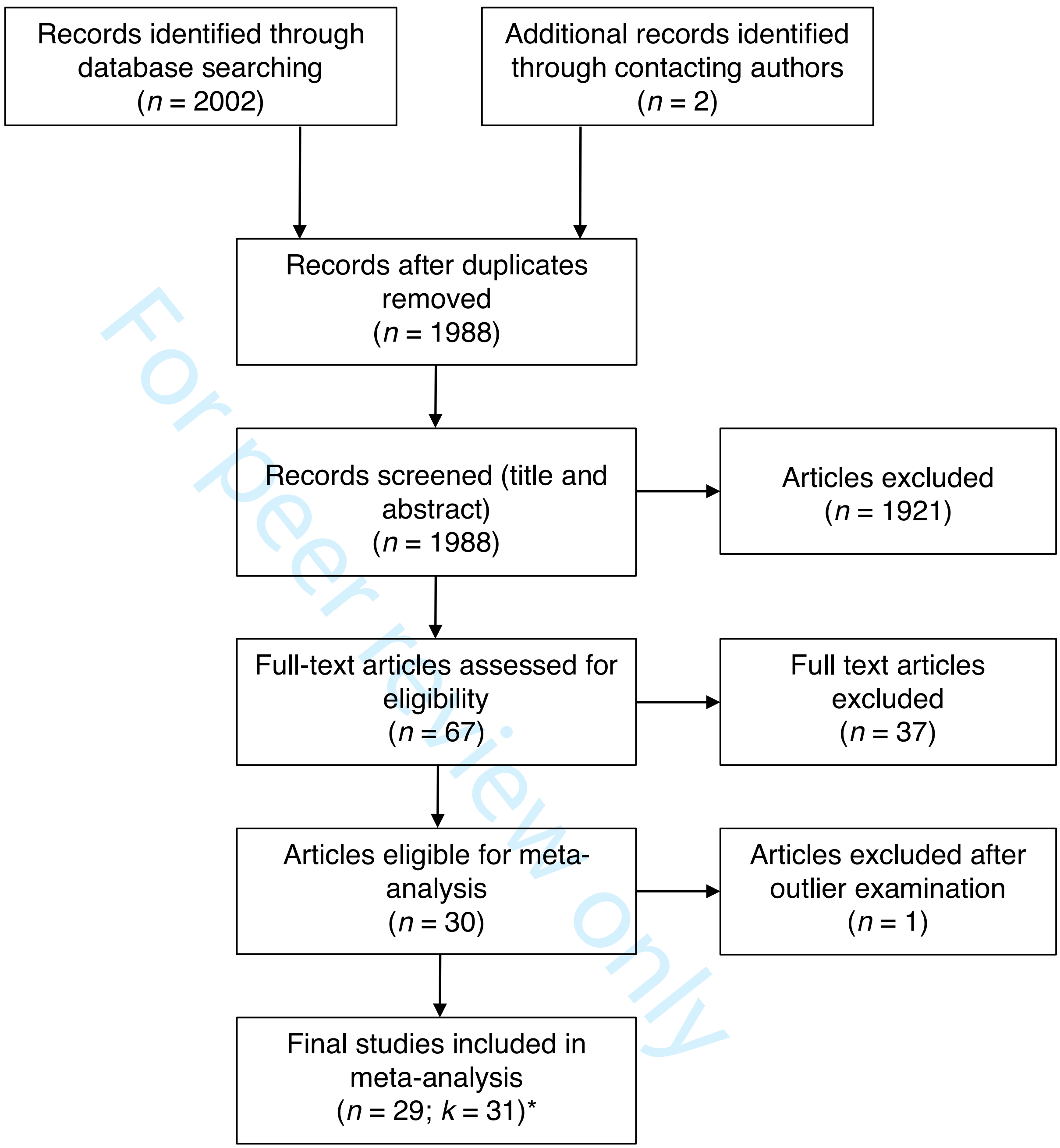
[a] Team size was entered as a continuous variable, therefore, no subgroup analyses exist

* $p < .05$.

LEGENDS TO FIGURES

Figure 1 Systematic literature search

Figure 2 Relationship between teamwork processes and performance


Records identified through database searching (n = 2002)
Additional records identified through contacting authors (n = 2)
Records after duplicates removed (n = 1988)
Records screened (title and abstract) (n = 1988)
Articles excluded (n = 1921)
Full-text articles assessed for eligibility (n = 67)
Full text articles excluded (n = 37)
Articles eligible for meta-analysis (n = 30)
Articles excluded after outlier examination (n = 1)
Final studies included in meta-analysis (n = 29; k = 31)*

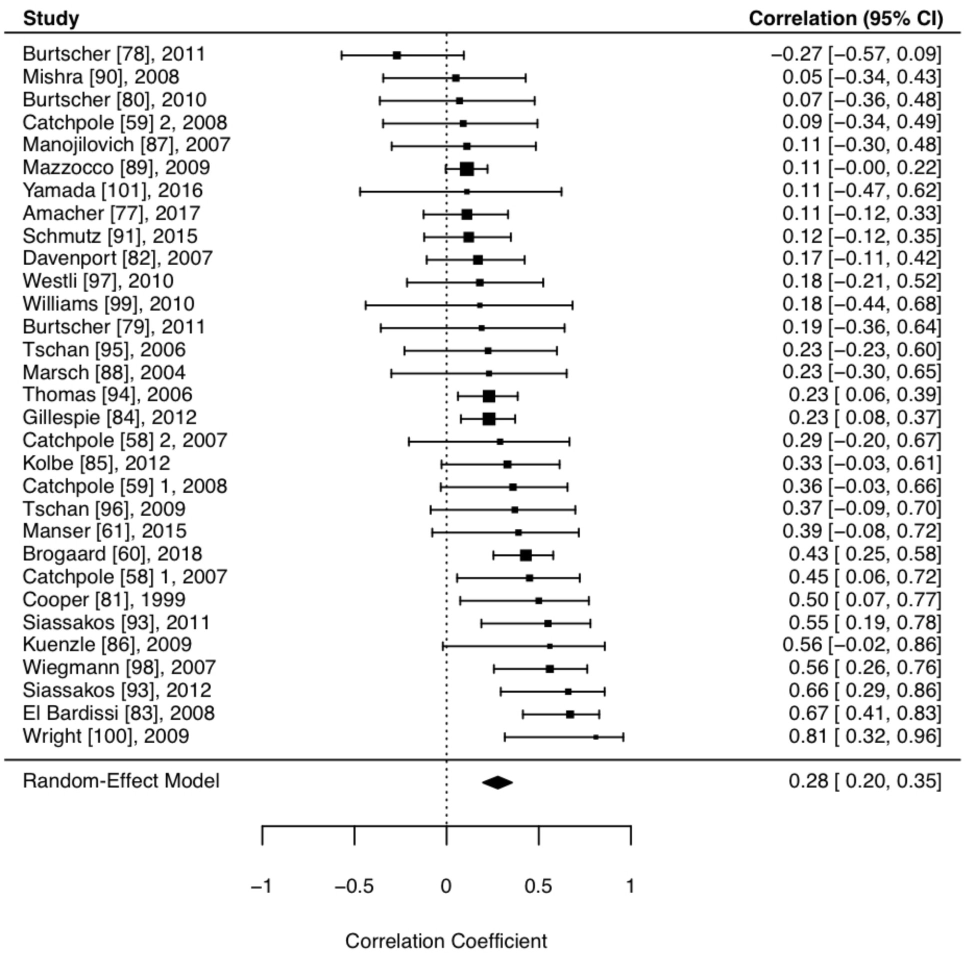


Figure 2. Relationship between teamwork processes and performance.

SUPPLEMENTARY FILE

Article: **How effective is teamwork really? The relationship between teamwork and performance in healthcare teams: A systematic review and meta-analysis**

Jan B. Schmutz, PhD, Laurenz L. Meier, PhD, Tanja Manser, PhD

Search terms used for PubMed search

(Teamwork[All Fields]) OR (team[All Fields] AND coordination[All Fields]) OR (team[All Fields] AND "decision making"[All Fields]) OR ((team[All Fields]) AND (communication[MeSH Terms]) OR (communication[All Fields])) OR (team[All Fields] AND leadership[All Fields]) AND (patient safety[MeSH Terms])

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4-8
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4-5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	n/a
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	9-10
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	9
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	9 and supplemental material
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	9-10
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	10
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	9-12
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	20
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	13-19 / 23

PRISMA 2009 Checklist

Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	20-23

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	20,26
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	22-23
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	21
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	18-19
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	18-19, 20
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	13-19
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	23
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	23
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	N/A
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	24-27
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	26-27
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	27
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	28

PRISMA 2009 Checklist

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

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BMJ Open

How effective is teamwork really? The relationship between teamwork and performance in healthcare teams: A systematic review and meta-analysis

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How effective is teamwork really? The relationship between teamwork and performance in healthcare teams: A systematic review and meta-analysis

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ABSTRACT

Objectives To investigate the relationship between teamwork and clinical performance and potential moderating variables of this relationship.

Design Systematic review and meta-analysis.

Data Source PubMed was searched in June 2018 without a limit on the date of publication. Additional literature was selected through a manual backward search of relevant reviews, manual backward and forward search of studies included in the meta-analysis and contacting of selected authors via e-mail.

Eligibility Criteria Studies were included if they reported a relationship between a teamwork process (e.g. coordination, non-technical skills) and a performance measure (e.g. checklist based expert rating, errors) in an acute care setting.

Data Extraction and Synthesis Moderator variables (i.e. professional composition, team familiarity, average team size, task type, patient realism and type of performance measure) were coded and random-effect models were estimated. Two investigators independently extracted information on study characteristics in accordance with PRISMA guidelines.

Results The review identified 2002 articles of which 31 were included in the meta-analysis comprising 1390 teams. The sample-sized weighted mean correlation was r = .28 (corresponding to an odds ratio of 2.8), indicating that teamwork is positively related to performance. The test of moderators was not significant, suggesting that the examined factors did not influence the average effect of teamwork on performance.

Conclusion Teamwork has a medium-sized effect on performance. The analysis of moderators illustrated that teamwork relates to performance regardless of characteristics of the team or task.

Therefore, healthcare organizations should recognize the value of teamwork and emphasize approaches that maintain and improve teamwork for the benefit of their patients.

ARTICLE SUMMARY

Strengths and limitations of this study

- This systematic review evaluates available studies investigating the effectiveness of teamwork processes.
- 31 studies have been included resulting in a substantial sample size of 1390 teams.
- The sample size of the primary studies included is usually low.
- For some subgroup analysis, the number of studies included was small.

INTRODUCTION

May it be an emergency team in the trauma room, paramedics treating patients after an accident or a surgical team in the operating room, teams are ubiquitous in healthcare and must work across professional, disciplinary and sectorial boundaries. Although the clinical expertise of individual team members is important to ensure high performance, teams must be capable of applying and combining the unique expertise of team members to maintain safety and optimal performance. In order for a team to be effective individual team members need to collaborate and engage in teamwork. Today, experts agree that effective teamwork anchors safe and effective care at various levels of the healthcare systems[1-4] leading to a relatively recent shift towards team research and training.[5-7]

Healthcare is an evidence-based field and therefore administrators and providers are seeking evidence in the literature concerning the impact of teamwork on performance outcomes like patient mortality, morbidity, infection rates or adherence to clinical treatment guidelines. Having a closer look at the literature investigating healthcare teams we find mixed and sometimes even contradicting results about the relationship between teamwork and clinical performance.[8] Some studies find a large effect of teamwork on performance outcomes (e.g. Carlson et al.[9]) while others report small or no relationships.[10,11] This inconsistency arises due to several reasons. First, the conceptual and empirical literature examining teamwork is fragmented and research examining teamwork effectiveness is spread across disciplines including medicine, psychology and organization science. Therefore, researchers and practitioners often lack a common conceptual foundation for investigating teams and teamwork in healthcare. Second, research studies on teamwork in healthcare usually exhibit small sample sizes because of the challenges of recruiting actual professional teams and carefully balancing research with patient

care priorities. Small sample sizes, however, increase the likelihood of reporting results that fail to represent true effect. Third, studies investigating healthcare teams often ignore important context variables of teams (e.g. team composition and size, task characteristics, team environment) that likely influence the effect that teamwork has on clinical performance.[12,13]

These inconsistencies in the teamwork literature may lead to confusion about the importance of teamwork in healthcare, thus giving voice to critics who hinder efforts to improve teamwork. We aim to address these problems with a meta-analytical study investigating the performance implications of teamwork. A meta-analytical approach moves beyond existing reviews on teamwork in healthcare[8,14-17] and quantitatively tests if the widely advocated positive effect of teamwork on performance holds true. In addition, this approach allows us to investigate context variables as moderators that may influence the effect of teamwork on performance, meaning that this effect might be stronger or weaker under certain conditions. Previous meta-analyses[18,19] focused mainly on the effectiveness of team trainings but not on the effect of teamwork itself. This meta-analysis will generate quantitative evidence to inform the relevance of future interventions, regulations and policies targeting teamwork in healthcare organizations.

In the following we will first establish an operational definition of teamwork, elaborate on relevant contextual factors, and present our respective meta-analytic results and their interpretation.

Teams, teamwork and team performance

In order to clearly understand the impact of teamwork on performance it is necessary to provide a brief introduction to teams, teamwork and team performance. We define teams as identifiable social work units consisting of two or more people with several unique

characteristics. These characteristics include *a)* dynamic social interaction with meaningful interdependencies; *b)* shared and valued goals*, c)* a discrete lifespan, *e)* distributed expertise and *f)* clearly assigned roles and responsibilities.[20,21] Based on this definition it becomes clear that teams must dynamically share information and resources amongst members and coordinate their activities in order to fulfil a certain task—in other words teams need to engage in *teamwork.*

Teamwork as a term is widely used and often difficult to grasp. However, we absolutely require a clear definition of teamwork especially for team trainings that target specific behaviours. *Teamwork* is a process that describes interactions among team members who combine collective resources to resolve task demands (e.g. giving clear orders).[22,23] Teamwork or team processes can be differentiated from *taskwork*. *Taskwork* denotes a team's individual interaction with tasks, tools, machines and systems.[23] *Taskwork* is independent of other team members and is often described as *what* a team is doing whereas *teamwork* is *how* the members of a team are doing something with each other.[24] Therefore, *team performance* represents the accumulation of teamwork and taskwork (i.e. what the team actually does).[25]

Team performance is often described in terms of inputs, processes and outputs (IPO).[22,26-28] *Outputs* like quality of care, errors or performance are influenced by team related *processes* (i.e. teamwork) like communication, coordination or decision making. Furthermore, these processes are influenced by various *inputs* like team members' experience, task complexity, time pressure and more. The IPO framework emphasizes the critical role of team processes as the mechanism by which team members combine their resources and abilities, shaped by the context, to resolve team task demands. It has been the basis of other more advanced models[27-29] but has also been criticized because of its simplicity.[30] However, it is still the most popular

framework to date and helps to systematize the mechanisms that predict team performance and represents the basis for the selection of the studies included in our meta-analysis.

Contextual factors of teamwork effectiveness

Based on a large body of team research from various domains, we hypothesize that several contextual and methodological factors might moderate the effectiveness of teamwork, indicating that teamwork is more important under certain conditions.[31,32] Therefore, we investigate several factors: (a) team characteristics (i.e. professional composition, team familiarity, team size); (b) task type (i.e. routine vs. non-routine tasks); (c) two methodological factors related to patient realism (i.e. simulated vs. real) and the type of performance measures used (i.e. process vs. outcome performance). In the following we discuss these potentially moderating factors and the proposed effects on teamwork.

Professional composition. We distinguished between interprofessional and uniprofessional teams. Interprofessional teams consist of members from various professions that must work together in a coordinated fashion.[33] Diverse educational paths in interprofessional teams may shape respective values, beliefs, attitudes and behaviours.[34] As a result team members with different backgrounds might perceive and interpret the environment differently and have a different understanding of how to work together. Therefore, we assume that explicit teamwork is especially important in interprofessional teams compared to uniprofessional teams.

Team familiarity. If team members have worked together, they are familiar with their individual working styles; and roles and responsibilities are usually clear. If a team works together for the first time, this potential lack of familiarity and clarity might make teamwork even more important. Therefore, we differentiate between *real teams* that also work together in

their everyday clinical practice and *experiential teams* that only came together for study purposes.

Team size. Another factor that may moderate the relationship between teamwork and performance is team size. Since larger teams exhibit more linkages among members than smaller teams, they also face greater coordination challenges. Also, with increasing size teams have greater difficulty developing and maintaining role structures and responsibilities. For these reasons, we expect the influence of teamwork on clinical performance to be stronger in larger teams as compared to smaller teams.

Task type. Routine situations are characterized by repetitive and unvarying actions (e.g. standard anaesthesia induction).[35] In contrast, non-routine situations exhibit more variation and uncertainty, requiring teams to be flexible and adaptive. Whereas team members mostly rely on pre-learned sequences during routine situations, during non-routine situations we assume that teamwork is more important in order for team members to resolve task demands.

Patient realism. Authors highlight the importance of using medical simulators in education.[36] Therefore, we investigate the realism used in a study (simulated vs. real patients) as a potential methodological factor that influences the relationship between teamwork and performance. Studies conducted with medical simulators might be more standardized and less influenced by confounding variables than studies conducted with real patients. Therefore, results from simulation studies might show stronger relationships between the two variables. Further, using a simulator could cause individuals and teams to act differently than in real settings, thereby distorting the results. However, in the last decade high-fidelity simulators have become increasingly realistic, suggesting that the results from simulation studies generalize to real environments. Including realism as a contextual factor in our analysis will reveal if the effects of

teamwork observed in simulation compare with real life settings. Better understanding would provide important insights about simulation use in teamwork studies.

Performance measures. As a second methodological factor, we expect that the type of performance measure used in a study influences the reported teamwork effectiveness. The literature usually differentiates between process- and outcome-related aspects of performance.[37,38] Process performance measures are action-related aspects and refer to adequate behaviour during procedures (e.g. adhering to guidelines), making them easier to assess. Outcome performance measures (e.g. infection rates after operations) follow team actions, with assessment occurring later than process measures. Outcome performance measures suffer from several factors: greater sensitivity to confounding variables (e.g. comorbidities), assessment challenges, and greater difficulty linking team processes to outcomes. Looking at the predictors of the survival of cardiac arrest patients illustrates the difference between the two types of performance measures. The main predictors for the survival (i.e. performance outcome) of a cardiac arrest patient are *"duration of the arrest"* and *"age of the patient less than 70"*.[39] Although a team delivers perfect basic life support (i.e. high process performance) the patient can still die (i.e. low outcome performance). Due to these methodological considerations, we expect that studies assessing process performance report a stronger relationship between teamwork and performance than studies assessing outcome performance.

METHODS

The study was conducted based on the recommendations of the PRISMA statement[40] as well as established guidelines in social sciences.[41,42] Through the combination of studies in the meta-analytical process, we will increase the statistical power and provide an accurate estimation of the true impact that teamwork has on performance.

Search strategy

We applied the following search strategy to select relevant papers: *a)* an electronic search of the data base PubMed (no limit was placed on the date of publication, last search 19th of June 2018) using the key words *teamwork*, *coordination*, *decision making*, *leadership* and *communication* in combination with *patient safety*, *clinical performance*, the final syntax for PubMed is available online (Supplementary File), b) a manual backwards search for all references cited by 8 systematic literature reviews that focus on teamwork or non-technical skills in various healthcare domains,[8,15,17,43-47] c) a manual backwards search for all references cited in studies we included in our meta-analysis, d) a manual forward search using Web of Science to identify studies that cite the studies we included in our meta-analysis, e) identification of relevant unpublished manuscripts via e-mail from authors currently investigating medical teams using specific mailing lists.

Inclusion criteria

Studies were included if a construct complied to the definition of teamwork processes outlined in the introduction (e.g. coordination, communication). In addition, studies needed to investigate the relationship between at least one teamwork process and a performance measure (e.g. patient outcome). When studies reported multiple estimates of the same relationship from

the same sample (e.g. between coordination and more than one indicator of performance), those correlations were examined separately only as appropriate for sub-analyses, but an average correlation was computed for all global meta-analyses of those relationships to maintain independence.[41] We excluded articles investigating long-term care since the coordination of care for chronically ill patients has to consider the unique team task interdependencies in this setting.[48] Also, teams working together over longer periods of time are more likely to develop emergent states (e.g. team cohesion) that influence how a specific team works together.[24] All articles included in this meta-analysis are listed in Table 1 and Table 2.

For the criterion level of analysis, we included only effect sizes at the team level and not on an individual level. Therefore, the performance measure had to be clearly linked to a team. This approach aligns with research that strongly recommends against mixing levels of analysis in meta-analytic integrations.[49,50]

Two reviewers independently screened titles and abstracts from articles yielded in the search. Afterwards full texts of all relevant articles were obtained and screened by the same two reviewers. Agreement was above 90%. Any disagreement in the selection process was resolved through consensus discussion.

Data extraction

With the help of a jointly developed coding scheme, studies were independently coded by one of the authors (JS) and another rater, both with a background in industrial psychology and human factors. 20% of the studies were rated by both coders. Intercoder agreement was above 90%. Any disagreement was resolved through discussion. The data extracted comprised details of the authors and publication as well as important study characteristics and statistical relationships between a teamwork variable and performance (Table 2).

Coding of team characteristics

The *professional composition* of teams was coded either as “Interprofessional” if a team consisted of members from different professions (e.g. nurses and physicians) or as “Uniprofessional” if the members of the teams were of the same profession. *Team size* was coded as the number of members (average number if team size varied) of the investigated teams. Team familiarity was coded either as “experimental” or “real”. “Real” indicates that the team members also worked together in their everyday clinical practice. “Experimental” means that the teams only worked together during the study.

Coding of task characteristics

Task type was coded either as “Routine task” or “Non-routine task”. We defined “Non-routine tasks” as unexpected events that require flexible behavior often under time-pressure (e.g. emergency situations). “Routine tasks” describe previously planned standard procedures (e.g. standard anesthesia induction, planned surgery).

Coding of methodological factors

Patient realism was either coded as “Real patient” or “Simulated patient”. “Simulated patient” included a patient simulator (manikin) whereas “Real patient” included real patients in clinical settings.

Clinical performance measures were coded either as “Outcome performance” or “Process performance”.[38,51] “Outcome performance” includes an outcome that is measured after the treatment process (e.g. infection rate, mortality). We focused only on patient-related outcomes and not on team outcomes (e.g. team satisfaction). "Process performance" describes the evaluation of the treatment process and describes how well the process was executed (e.g. adherence to guidelines through expert rating). Process performance measures are often based on official guidelines and extensive expert knowledge.[52] Thus, we assumed that process performance closely relates to patient outcomes.

Statistical Analysis

Different types of effect sizes (e.g. Odds ratio, *F* values, and *r*) have been reported in the original studies. We therefore converted the different effect sizes to a common metric, namely *r* using the formulas provided by Borenstein et al.[53] and Walker.[54] Moreover, some samples contained effect sizes of teamwork with two or more measures of performance. Because independence of the included effects sizes is required for a meta-analysis,[41,55] we used Fisher's z score to average the multiple correlations from the same sample[1]. The correlations were weighted for sample size. However, in contrast to many meta-analyses in social sciences, the correlations were not adjusted for measurement reliability. This is because information about the measurement reliability could not be compared (Kappa vs. Cronbach Alpha) or were not available at all for the majority of studies. Therefore, we report uncorrected, sample-size weighted mean correlation, its 95% confidence interval (CI), and the 80% credibility interval (CR). The CI reflects the accuracy of a point estimate and can be used to examine the significance of the effect size estimates, whereas the CR refers to the deviation of these estimates and informs us about the existence of possible moderators.

[1] Scholars have suggested to convert *r* to Fisher's z scores, to average the z's, and then to backtransform it to *r*.[56] Using simple arithmetic average (i.e., correlations will be summed and divided by the number of coefficients) is problematic because the distribution of *r* becomes negatively skewed as the correlation is larger than zero. As a result, the average *r* tends to underestimate the population correlation.

Random-effects models were estimated based on two considerations.[57] First, we expected study heterogeneity to be high given the different study design characteristics such as *patient realism* ("Real patient" vs. "Simulated patient"), *task type* ("Routine task" vs. "Non-routine task"), and different forms of performance measures. Second, we aimed to provide an inference on the average effect in the entire population of studies from which the included studies are assumed to be a random selection of it. Therefore, random-effects models were estimated.[57] These models were calculated by the restricted maximum-likelihood estimator, an efficient and unbiased estimator.[58] Since we included only descriptive studies and no interventions we only included the sample size of the individual studies as a potential bias into the meta-analysis. To rule out a potential publication bias, we tested for funnel plot asymmetry using the random-effect version of the Egger test.[59] The results indicate that there is no asymmetry in the funnel plot ($z = 1.79$, $p = .074$), suggesting that there is no publication bias.

The estimation of meta-analytical models including the outlier analyses were performed with the package "metafor" from the programming language and statistical environment R.[58]

Patient and public involvement

Patients and public were not involved in this study.

RESULTS

The online search resulted in 2002 articles (Figure 1). Two studies were identified via contacting authors directly and have been presented at conferences in the past.[60,61] After duplicates were removed 1988 articles were screened using title and abstract. 67 articles were then selected for a full text review. Full text examination, forward and backward search of selected articles and relevant reviews resulted in 30 studies coming from 28 articles (Two publications presented two independent studies in one publication[62,63]). This led to a total of 32 studies coming from 30 articles. Following the recommendation by Viechtbauer and Cheung,[64] we screened for outliers using studentized deleted residuals. One case (Carlson et al.,[9] r = .89, n = 44, studentized deleted residuals = 4.26) was identified as outlier and therefore excluded from further analyses, resulting in a final sample size of k = 31.

Table 1 provides a qualitative description of the selected articles including study objectives, the setting in which the studies were carried out and a description of the teamwork processes as well as the outcome measures that were assessed. If a specific tool for the assessment of a teamwork process or outcome measure was used this is indicated in the corresponding column. Observational studies were most prevalent. Teamwork processes were assessed using either behaviourally anchored rating scales (N=8) or structured observation (N=19) of specific teamwork behaviour. Structured observation—as we describe it—is defined as a purely descriptive assessment of certain behaviour usually using a predefined observation system (e.g. amount of speaking up behaviour). In contrast, behaviourally anchored rating scales consist of an evaluation of teamwork process behaviour by an expert. Only three studies used surveys to assess teamwork behaviours. The majority of the studies (N=27) assessed process performance using either a checklist-based expert rating or assessing a reaction time measure after the occurrence of a certain event (e.g. time until intervention). Only four studies assessed outcome performance measures. Measures included accuracy of diagnosis, postoperative complications and death, surgical morbidity and mortality, ventilator-associated pneumonia, bloodstream infections, pressure ulcers and acute physiology and chronic health evaluation score. Table 2 provides an overview of all variables included in the meta-analysis including the effect sizes and moderator variables.

Effect of teamwork and contextual factors

Table 3 and Figure 2 shows the relationship between teamwork and team performance. The sample-sized weighted mean correlation was .28 (95% CI: .20 to .35, $z = 6.55$, $p < .001$), indicating that teamwork is positively related to clinical performance. Results further indicated heterogeneous effect size distributions across the included samples ($Q = 53.73$, $p < .05$, $I^2 = 45.96$), signifying that the variability across the sample effect sizes was more than what would be expected from sampling error alone.

To test for moderator effects of the contextual factors, we conducted mixed-effects models including the mentioned moderators: *professional composition, team familiarity, team size, task type, patient realism* and *performance measures.*

The omnibus test of moderators was not significant ($F = 0.18$, $df_1 = 6$, $df_2 = 18$, $p > .20$), suggesting that the examined contextual factors did not influence the average effect of teamwork on clinical performance. To provide greater detail about the role of the contextual factors, we conducted separate analyses for the categorical contextual factors and report them in Table 3.

DISCUSSION

With this study, we aimed to provide evidence for the performance implications of teamwork in healthcare teams. By including various contextual factors, we investigated potential contingencies that these factors might have on the relationship between teamwork and clinical performance. The analysis of 1390 teams from 31 different studies showed that teamwork has a medium sized effect (r=.28; [65,66]) on clinical performance across various care settings. Our study is the first to investigate this relationship quantitatively with a meta-analytical procedure. This finding aligns with and advances previous work that explored this relationship in a qualitative way.[8,15,17,43-47]

At first glance a correlation of r=.28 might not seem very high. However, we would like to highlight that r=.28 is considered a medium sized effect[65,66] and should not be underestimated. To better illustrate what this effect means we transformed the correlation into an odds ratio (OR) of 2.8.[53] Of course, this transformation simplifies the correlation because teamwork and often the outcome measures are not simple dichotomous variables that can be divided into an intervention and control group. However, this transformation illustrates that teams who engage in teamwork processes are 2.8 times more likely to achieve high performance than teams who are not. Looking at the performance measures in our study we see that they either describe patient outcomes (e.g. mortality, morbidity) or are closely related to patient outcomes (e.g. adherence to treatment guidelines). Thus, we consider teamwork a performance-relevant process that needs to be promoted through training and implementation into treatment guidelines and policies.

The included studies used a variety of different measures for clinical performance. This variability resulted from the different clinical contexts in which the studies were carried out.

There is no universal measure for clinical performance because the outcome is in most cases context specific. In surgery, common performance measures are surgical complications, mortality or morbidity.[67] In anaesthesia, studies often use expert ratings based on checklists to assess the provision of anaesthesia. Expert ratings are also the common form of performance assessment in simulator settings where patient outcomes like morbidity or mortality cannot be measured. Future studies need to be aware that clinical performance measures depend on the clinical context and that the development of valid performance measures requires considerable effort and scientific rigor. Guidelines on how to develop performance assessment tools for specific clinical scenarios exist and need to be accounted for.[52,68,69] Furthermore, depending on the clinical setting researchers need to evaluate what specific clinical performance measures are suitable and if and how they can be linked to team processes in a meaningful way.

The analysis of moderators illustrates that teamwork is related with performance under a variety of conditions. Our results suggest that teams in different contexts characterised by different team constellations, team size and levels of acuity of care all benefit from teamwork. Therefore, clinicians and educators from all fields should strive to maintain or increase effective teamwork. In recent years, there has been an upsurge in crisis resource management (CRM).[19] These trainings focus on team management and implement various teamwork principles during crisis situations (e.g. emergencies).[70] Our results suggest that team trainings should not only focus on non-routine situations like emergencies but also on routine situations (e.g. routine anaesthesia induction, routine surgery) because based on our data teamwork is equally important in such situations.

A closer look at methodological factors of the included studies revealed that the observed relationship between teamwork and performance in simulation settings does not differ from

relationships observed in real settings. Therefore, we conclude that teamwork studies conducted in simulation settings generalize to real life settings in acute care. Further, the analysis of different performance measures reveals a trend towards process performance measures being more strongly related with teamwork than outcome performance measures. A possible explanation of this finding relates to the difficulty of investigating outcome performance measures in a manner isolated from other variables. Nevertheless, we still found a significant relationship between teamwork and objective patient outcomes (e.g. postoperative complications, bloodstream infections) despite the methodological challenges of measuring outcome performance and the small number of studies using outcome performance ($k = 4$).

Our results are in line with previous meta-analyses investigating the effectiveness of team training in healthcare.[18,19] Similar to our results, Hughes et al. highlighted the effectiveness of team trainings under a variety of conditions—irrespective of team composition,[18] simulator fidelity or patient acuity of the trainee's unit as well as other factors.

We were unable to find a moderation of task type in our study, potentially explained by task interdependence, which reflects the degree to which team members depend on one another for their effort, information, and resources.[71] A meta-analysis including teams from multiple industries (e.g. project teams, management teams) found that task interdependence moderates the relationship between teamwork and performance, demonstrating the importance of teamwork for highly interdependent team tasks.[72] Most studies included in our analysis focused on rather short and intense patient care episodes (e.g. a surgery, a resuscitation task) with high task interdependence, which may explain the high relevance of teamwork for all these teams.

Limitations and future directions

Despite greater attention to healthcare team research and team training over the last decade, we were only able to identify 32 studies (31 included in the meta-analysis). Of note, over two-thirds of the studies in our analysis emerged in the last 10 years, reflecting the increasing interest in the topic. The rather small number of studies might relate to the difficulties in quantifying teamwork, the considerable theoretical and methodological knowledge required, and the challenges of capturing relevant outcome measures. Also, besides the manual searches of selected articles and reviews and contacting authors in the field we did only search the data base PubMed. PubMed is the most common database to access papers that potentially investigate medical teams and includes approximately 30'000 journals from the field of medicine, psychology and management. We are fairly confident that through the additional inclusion of relevant reviews and forward and backwards search, our results represent an accurate representation of what can be found in the literature.

Future research should build on recent theoretical and applied work[24,26,28,73] about teamwork and use this current meta-analysis as a signpost for future investigations. In order to move our field forward, we must use existing conceptual frameworks[22,24,26] and establish standards for investigating teams and teamwork. This can often only be achieved with interdisciplinary research teams including experts from the medical fields but equally important from health professions education, psychology or communication studies.

Another limitation relates to the unbalanced analysis of subgroups. For example, we only identified four studies that used outcome performance variables compared to 27 using process performance measures. Uneven groups may reduce the power to detect significant differences.

Therefore, we encourage future studies to include outcome performance measures despite the effort required.

Finally, more factors may influence the relationship between teamwork and performance that we were unable to extract from the studies. While we tested for the effects of team familiarity by comparing experimental teams and real teams, this does not fully capture team member familiarity. The extent to which team members actually worked together during prior clinical practice might predict of how effectively they perform together. However, even two people working in the same ward might actually not have interacted much during patient care depending on the setting. Also team climate on a ward or in a hospital may be an important predictor of how well teams work together, especially related to sharing information or speaking up within the team.[74,75]

Finally, the clinical context might play a role in how team members collaborate. In different disciplines, departments or healthcare institutions different norms and routines exist on how to work together. Therefore, study results and recommendations about teamwork need to be interpreted in the light of the respective clinical context. There are empirical indications that a one-size-fits-all approach might not be suitable and team training efforts cannot ignore the clinical context, especially the routines and norms about collaboration.[76] We acknowledge that there might be other factors surrounding healthcare teams that might potentially influence teamwork and clinical performance. However, in this review we could only extract data that was reported in the primary studies. Since these were limited in the healthcare contexts studied, the results might not generalise to long-term care settings or mental health, for example. Future work needs to consider and also document a broader range of potentially influencing factors.

Conclusion

The current meta-analysis confirms that teamwork across various team compositions represents a powerful process to improve patient care. Good teamwork can be achieved by joint reflection about teamwork during clinical event debriefings[77,78] as well as team trainings[79] and system improvement. All healthcare organisations should recognise these findings and place continuous efforts into maintaining and improving teamwork for the benefit of their patients.

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Table 1. Descriptions of study objectives, settings and description of teamwork process and outcome measures

Authors	Year	Main study objectives	Participants and setting	Teamwork process measure	Outcome measure
Amacher, Schumacher, Legeret, et al.[80]	2017	To compare female and male rescuers in regard to cardiopulmonary resuscitation and leadership performance	Video observation of medical students managing cardiopulmonary resuscitation in a high-fidelity patient simulator	Structured observation of secure leadership statements within teams	Time until start chest compression Hands-on time within first 180 seconds
Brogaard, Kierkegaard, Hvidmand, et al.[60]	2018	To investigate the relationship between non-technical skills and clinical performance in obstetric teams	Video observation of obstetric teams (Obstetricians, obstetric nurse, anaesthesiologists) managing real-life emergencies (postpartum haemorrhage)	Assessment of non-technical skills using a behaviourally anchored rating scale (ATOP; Assessment of Obstetric Team Performance)	Checklist tool for clinical performance (TeamOBS-PPH)
Burtscher, Kolbe, Wacker, et al.[81]	2011	To investigate how team mental models and team monitoring behaviour interact to predict team performance in anaesthesia	Video observation of anaesthesia teams (residents, nurses) conducting a standard anaesthesia induction using a high-fidelity patient simulator	Structured observation of team monitoring behaviour	Checklist based expert rating
Burtscher, Manser, Kolbe, et al.[82]	2011	To investigate the relationship between adaptation of team coordination and clinical performance in response to a critical event	Video observation of anaesthesia teams (resident, nurse) conducting a standard anaesthesia induction including a critical event using a high-fidelity patient simulator	Structured observation of team coordination	Reaction time related to the critical event
Burtscher, Wacker, Grote, et al.[83]	2010	To examine the role of anaesthesia teams' adaptive coordination in managing changing situational demands	Video observation of anaesthesia teams (residents, nurses, students) conducting standard anaesthesia inductions with non-routine events	Structured observation of team coordination	Checklist based expert rating

Carlson, Min, Bridges[9]	2009	To explore the relationship between team behaviour and the delivery of an appropriate standard of care specific to the simulated case	Video observation of trainees participating in a simulated event involving the presentation of acute dyspnoea	Assessment of team behaviour using a behaviourally anchored rating scale (leadership and team behaviour measurement tool)	Checklist based expert rating
Catchpole, Giddings, Wilkinson, et al.[62]	2007	To investigate if effective teamwork can prevent the development of serious situations and provide evidence for improvements in training and systems	Live observation of surgical teams conducting paediatric cardiac and orthopaedic surgeries	Observation of non-technical skills using a behaviourally anchored rating scale (NOTECHS scoring system)	Assessment of minor problems, intraoperative performance and duration of surgery
Catchpole, Mishra, Handa, et al.[63]	2008	To analyse the effects of surgical, aesthetic, and nursing teamwork skills on technical outcomes	Observation of surgical teams conducting laparoscopic cholecystectomies and carotid endarterectomies	Observation of non-technical skills using a behaviourally anchored rating scale (NOTECHS scoring system)	Operating time and errors in surgical technique
Cooper, Wakelam[84]	1999	To examine the relationship between leadership behaviour, team dynamics and task performance	Video observation of emergency teams managing full cardiopulmonary arrests with a resuscitation attempt lasting longer than 3 minutes	Survey about leadership behaviour using the Leadership Behaviour Description Questionnaire	Checklist based expert rating
Davenport, Henderson, Mosca, et al.[85]	2007	To measure the impact of organizational climate safety factors on risk-adjusted surgical morbidity and mortality	Survey of staff on general and vascular surgery services	Survey about teamwork climate, level of communication and collaboration with surgeon	Surgical morbidity Surgical mortality
El Bardissi, Wiegmann, Henrickson, et al.[86]	2008	To identify patterns of teamwork failures that would benefit from intervention in the cardiac surgical setting	Live observation of surgical teams conducting cardiac surgery	Structured observation of teamwork failures that disrupted the flow of the operation	Surgical technical errors
Gillespie, Chaboyer, Fairweather[87]	2012	To investigate how various human factors variables, extend the expected length of an operation	Live observation of surgical teams across 10 specialties	Structured observation of numbers of communication failures	Deviation from expected length of operation

Kolbe, Burtscher, Wacker, et al.[88]	2012	To test the relationship between speaking up and technical team performance in anaesthesia.	Observation of 2-person (nurse, resident) ad hoc anaesthesia teams performing simulated inductions of general anaesthesia with minor nonroutine events	Structured observation of speaking up behaviour	Checklist based expert rating
Kuenzle, Zala-Mezo, Wacker, et al.[89]	2009	To investigate shared leadership patterns during anaesthesia induction and to show how they are linked to team performance	Observation of 2-person (nurse, resident) ad hoc anaesthesia teams performing simulated inductions of general anaesthesia with a nonroutine event (asystole)	Structured observation of leadership behaviour	Reaction time to nonroutine event
Manojilovich, Antonakos, David, et al.[90]	2009	To determine the relationships between patients' outcomes and nurses' perceptions of communication and characteristics of the practice environment.	A survey was conducted with nurses on various ICU wards	Survey about perception of nurse-physician communication using the ICU-nurse physician questionnaire	Ventilator-associated pneumonia Bloodstream infections Pressure ulcers Acute physiology and chronic health evaluation score
Manser, Bogdanovic, Clack, et al. [61]	2015	To investigate surgeons team management skills and its influence on performance	Live observation of surgical teams managing a simulated laparoscopic cholecystectomy	Structured observation of team management using the ComEd-E observation system	Checklist based expert rating
Marsch, Müller, Marquardt, et al.[91]	2004	To determine whether and how human factors affect the quality of cardiopulmonary resuscitation	Observation of healthcare worker (nurse, physician) managing a cardiac arrest due to ventricular fibrillation using a high-fidelity patient simulator	Structured observation of task distribution, information transfer and leadership behaviour within the team	Checklist based expert rating
Mazzocco, Petitti, Fong, et al.[92]	2009	To determine if patients of teams with good teamwork had better outcomes than those with poor teamwork	Live observation of surgical teams managing a variety of surgical procedures	Structured observation of information sharing, inquiry for relevant information and vigilance and awareness using a behaviourally anchored rating scale	Postoperative complications and death

Mishra, Catchpole, Dale, et al.[93]	2008	To report on the development and evaluation of a method for measuring operating-theatre teamwork quality	Live observation of surgical teams conducting laparoscopic cholecystectomy	Assessment of non-technical skills using a behaviourally anchored rating scale (NOTECHS scoring system)	Surgical technical errors assessed with the OCHRA-tool
Schmutz, Hoffmann, Heimberg, et al.[94]	2015	To investigate the moderating effect of task characteristics on the relationship between coordination and performance	Video observation of paediatric teams managing various paediatric emergencies using a high-fidelity patient simulator	Structured observation of closed loop communication, task distribution and provide information without request using the CoMeT-E observation system	Checklist based expert rating
Siassakos, Bristowe, Draycott, et al.[95]	2012	To investigate the relationship between patient satisfaction and communication	Video observation of teams (physicians, midwives) managing obstetric emergencies in secondary and tertiary maternity units	Structured observation of closed loop communication	Timely administration of magnesium sulphate
Siassakos, Fox, Crofts, et al.[96]	2011	To determine whether team performance in a simulated emergency is related to generic teamwork skills and behaviors	Video observation of healthcare professionals (physician, midwives) managing various emergencies using a high-fidelity patient simulator	Assessment of generic teamwork using a behaviourally anchored rating scale (teamwork analytical tool)	Clinical efficiency score
Thomas, Sexton, Lasky, et al.[97]	2006	To investigate the relationship of team behaviours during delivery room care and behaviours relate to the quality of care	Video observation of neonatal care teams managing a resuscitation during a caesarean section	Structured observation of communication, team management and leadership	Compliance with Neonatal Resuscitation Program guidelines
Tschan, Semmer, Gautschi, et al.[98]	2006	To investigate the influence of human factors on team performance in medical emergency driven groups	Video observation of medical emergency teams (senior doctor, resident, nurse) managing a cardiac arrest in a high-fidelity patient simulator	Structured observation of directive leadership and structuring inquiry	Clinical performance assessed based on a time-based coding of observable technical acts

Tschan, Semmer, Gurtner, et al.[99]	2009	To investigate the influence of communication on diagnostic accuracy in ambiguous situations	Video observation of groups of physicians diagnosing a difficult patient with an anaphylactic shock in a high-fidelity patient simulator	Structured observation of the diagnostic information that have been considered, explicit reasoning and talking to the room	Accuracy of diagnosis
Westli, Johnsen, Eid, et al.[100]	2010	To investigate whether demonstrated teamwork skills and behaviour indicating shared mental models would be associated with improved medical management	Video observation of trauma teams (surgeons, anaesthesiologists, nurses, radiographers) in a high-fidelity patient simulator	Assessment of non-technical skills using a behaviourally anchored rating scale (ANTS and ATOM scoring system)	Checklist based expert rating
Wiegmann, El Bardissi, Dearani, et al.[101]	2007	To investigate surgical errors and their relationship to surgical flow disruptions to understand better the effect of these disruptions on surgical errors and patient safety	Live observation of surgical teams conducting cardiac surgery operations	Structured observation of teamwork and communication failures	Structured observation of surgical errors during the operation
Williams, Lasky, Dannemiller, et al.[102]	2010	To describe relationships between teamwork behaviours and errors during neonatal resuscitation	Video observation of intensive care teams managing neonatal resuscitations	Structured observation of teamwork behaviour (vigilance, workload management, information sharing, inquiry, assertion)	Structured observation of errors (non-compliance with guidelines)
Wright, Phillips-Bute, Petrusa, et al.[103]	2009	To test if observer ratings of team skills will correlate with objective measures of clinical performance	Video observation of teams consisting of medical students performing low-fidelity classroom based patient assessment and high-fidelity simulation emergent care.	Observation using a behaviourally anchored rating scale for teamwork skills (assertiveness, decision-making, situation assessment, leadership, communication)	Checklist based expert rating
Yamada, Fuerch, Halamek[104]	2016	To investigate the effect of standardized communication techniques on errors during resuscitation	Video observation of teams (Neonatologists, neonatal nurse practitioners, neonatology fellows) managing neonatal resuscitation	Structured observation of standardised communication	Error rate Time to initiate positive pressure ventilation Time to chest compression

Table 2. Studies, effect sizes and moderator variables included in the meta-analytic database

Authors	Year	Study goal	Setting	No. of teams	Professional composition	Team familiarity	Average team size	Task type	Patient realism	Performance measure
Amacher, Schumacher, Legeret, et al.[80]	2017	.11	Emergency medicine	72	Uniprofessional	Experimental	3	Non-routine	Simulated	Process
Brogaard, Kierkegaard, Hvidmand, et al.[60]	2018	.43	Obstetrics	99	Interprofessional	Real	5	Non-routine	Real	Process
Burtscher, Kolbe, Wacker, et al.[81]	2011	-.27	Anaesthesia	31	Interprofessional	Experimental	2	Routine	Simulated	Process
Burtscher, Manser, Kolbe, et al.[82]	2011	.19	Anaesthesia	15	Interprofessional	Experimental	2	Routine & non-routine	Simulated	Process
Burtscher, Wacker, Grote, et al.[83]	2010	.07	Anaesthesia	22	Interprofessional	Real	3	Non-routine	Real	Process
Carlson, Min, Bridges[9][b]	2009	.83	Emergency medicine	44	Uniprofessional	Experimental	2.6	Non-routine	Simulated	Process
Catchpole, Giddings, Wilkinson, et al.[62]	2007	.45†	Surgery	24	Interprofessional	Real	9	Non-routine	Real	Process
	2007	.29†	Surgery	18	Interprofessional	Real	5	Routine	Real	Process
Catchpole, Mishra, Handa, et al.[63]	2008	.36†	Surgery	26	Interprofessional	Real		Routine	Real	Process
	2008	.09†	Surgery	22	Interprofessional	Real		Routine	Real	Process
Cooper, Wakelam[84]	1999	.50	General care	20	Interprofessional	Real	4	Routine	Real	Process
Davenport, Henderson, Mosca, et al.[85]	2007	.17	Surgery	52	Interprofessional	Real		Routine	Real	Outcome
El Bardissi, Wiegmann, Henrickson, et al.[86]	2008	.67	Surgery	31	Interprofessional	Real	7	Routine	Real	Process
Gillespie, Chaboyer, Fairweather[87]	2012	.23	Surgery	160	Interprofessional	Real	6	Routine	Real	Process
Kolbe, Burtscher, Wacker, et al.[88]	2012	.33	Anaesthesia	31	Interprofessional	Real	2	Non-routine	Simulated	Process
Kuenzle, Zala-Mezo, Wacker, et al.[89]	2009	.56	Anaesthesia	12	Interprofessional	Real	2	Routine	Simulated	Process
Manojilovich, Antonakos, David, et al.[90]	2009	.11	Intensive care	25	Uniprofessional	Real	36	Routine	Real	Outcome

Manser, Bogdanovic, Clack, et al.[61]	2015	.39	Surgery	19	Interprofessional	Experi-mental	5	Routine	Simulated	Process
Marsch, Müller, Marquardt, et al.[91]	2004	.23	Intensive care	16	Interprofessional	Experi-mental	3	Non-routine	Simulated	Process
Mazzocco, Petitti, Fong, et al.[92]	2009	.11	Surgery	293	Interprofessional	Real	6	Routine	Real	Outcome
Mishra, Catchpole, Dale, et al.[93]	2008	.05	Surgery	26	Interprofessional	Real	6	Routine	Real	Process
Schmutz, Hoffmann, Heimberg, et al.[94]	2015	.12	Emergency medicine	68	Interprofessional	Real	6	Non-routine	Simulated	Process
Siassakos, Bristowe, Draycott, et al.[95]	2012	.66	Obstetrics	19	Interprofessional	Real	6	Non-routine	Simulated	Process
Siassakos, Fox, Crofts, et al.[96]	2011	.55	Emergency medicine/ obstetrics	24	Interprofessional	Experi-mental	6	Non-routine	Simulated	Process
Thomas, Sexton, Lasky, et al.[97]	2006	.23	Neonatal care	132	Interprofessional	Real	5	Non-routine	Real	Process
Tschan, Semmer, Gautschi, et al.[98]	2006	.23	Emergency medicine	21	Interprofessional	Experi-mental	5	Non-routine	Simulated	Process
Tschan, Semmer, Gurtner, et al.[99]	2009	.37	Emergency medicine	20	Uniprofessional	Experi-mental	2.65	Non-routine	Simulated	Outcome
Westli, Johnsen, Eid, et al.[100]	2010	.18	Emergency medicine	27	Interprofessional	Real	5.1	Non-routine	Simulated	Process
Wiegmann, El Bardissi, Dearani, et al.[101]	2007	.56	Surgery	31	Interprofessional	Real		Routine	Real	Process
Williams, Lasky, Dannemiller, et al.[102]	2010	.18	Neonatal care	12	Interprofessional	Real	5	Non-routine	Real	Process
Wright, Phillips-Bute, Petrusa, et al.[103]	2009	.81	General care	9	Uniprofessional	Experi-mental	4	Non-routine	Simulated	Process
Yamada, Fuerch, Halamek[104]	2016	.11	Emergency medicine	13	Interprofessional	Experi-mental	3	Non-routine	Simulated	Process

[a] Effect sizes (*r*) with an † represent an average for a single sample and a single outcome and have been combined for this meta-analysis.

[b] Carlson, Min & Bridges has been identified as an outlier and therefore excluded from the analysis

Table 3. Meta-Analytic relationships between teamwork and clinical performance

	N	k	r	95% CI	80% CR	Q	I^2
Overall relationship	1,390	31	.28*	[.20 ; .35]	[.09 ; .45]	53.7*	46.0
Team characteristics							
Professional composition							
Interprofessional	1,264	27	.28*	[.20 ; .36]	[.09 ; .46]	47.1*	48.2
Uniprofessional	126	4	.28	[-.01 ; .52]	[-.04 ; .54]	6.5	47.1
Team familiarity							
Experimental team	240	10	.25*	[.05 ; .43]	[-.05 ; .51]	17.2*	47.2
Real team	1,150	21	.29*	[.20 ; .37]	[.12 ; .45]	36.2*	45.7
Team size[a]							
Task characteristics							
Task type							
Routine task	766	14	.27*	[.12 ; .40]	[-.01 ; .50]	30.9*	65.0
Non-routine task	609	16	.29*	[.20 ; .39]	[.16 ; .42]	20.5	24.6
Methodological factors							
Patient realism							
Real patient	993	16	.28*	[.18 ; .38]	[.10 ; .45]	28.7*	49.3
Simulated patient	397	15	.28*	[.13 ; .41]	[.02 ; .50]	25.0*	44.6
Performance measures							
Outcome performance	390	4	.13*	[.03 ; .23]	[.06 ; .19]	1.3	0.0
Process performance	1,000	27	.30*	[.21 ; .39]	[.10 ; .49]	45.6*	45.6

Note. *k* = number of studies; *N* = cumulative sample size (number of teams); *r* = sample-size weighted correlation; CI = confidence interval; CR = credibility interval; *Q* = test statistic for residual heterogeneity of the models; I^2 = % of total variability in the effect size estimates due to heterogeneity among true effects (vs. sampling error)

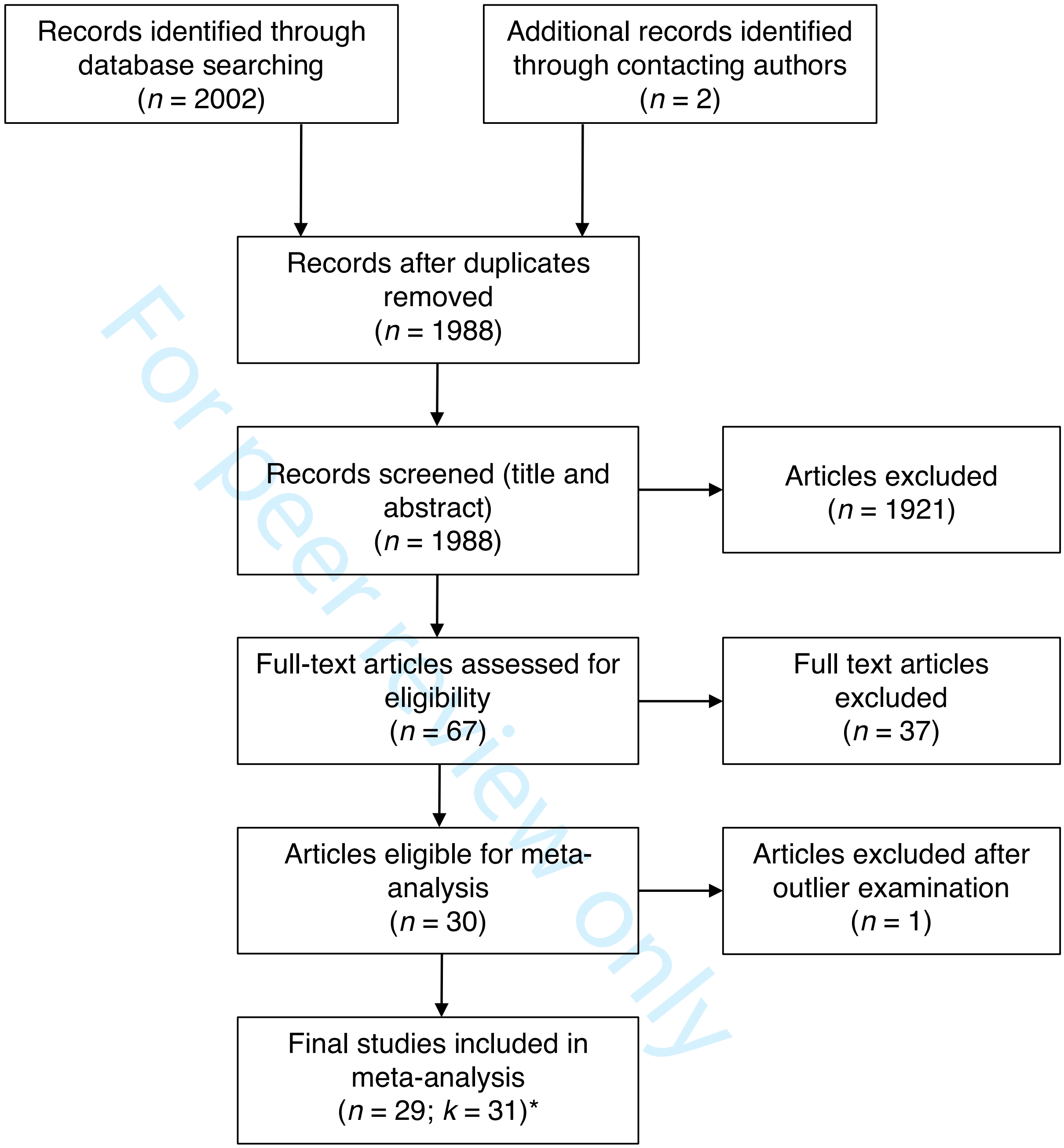
[a] Team size was entered as a continuous variable, therefore, no subgroup analyses exist

* $p < .05$.

LEGENDS TO FIGURES

Figure 1 Systematic literature search

Figure 2 Relationship between teamwork processes and performance


Records identified through database searching (n = 2002)
Additional records identified through contacting authors (n = 2)
Records after duplicates removed (n = 1988)
Records screened (title and abstract) (n = 1988)
Articles excluded (n = 1921)
Full-text articles assessed for eligibility (n = 67)
Full text articles excluded (n = 37)
Articles eligible for meta-analysis (n = 30)
Articles excluded after outlier examination (n = 1)
Final studies included in meta-analysis (n = 29; k = 31)*

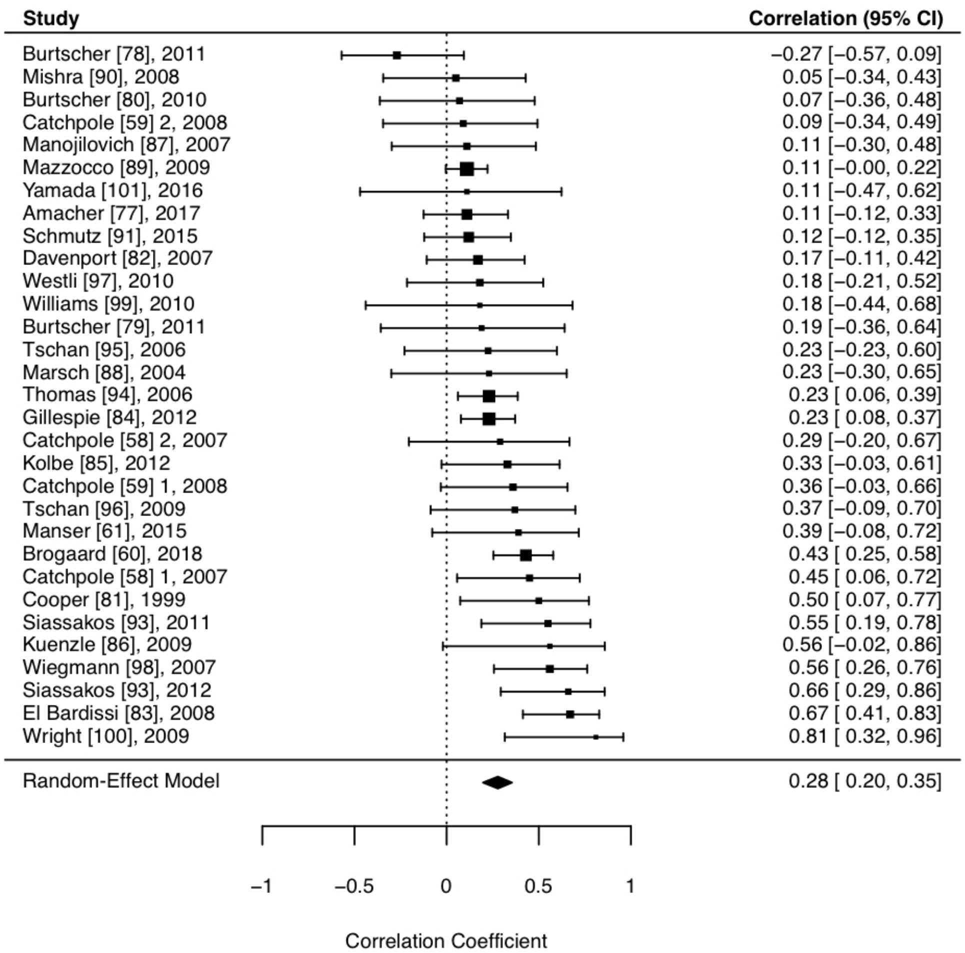


Figure 2. Relationship between teamwork processes and performance.

SUPPLEMENTARY FILE

Article: **How effective is teamwork really? The relationship between teamwork and performance in healthcare teams: A systematic review and meta-analysis**

Jan B. Schmutz, PhD, Laurenz L. Meier, PhD, Tanja Manser, PhD

Search terms used for PubMed search

(Teamwork[All Fields]) OR (team[All Fields] AND coordination[All Fields]) OR (team[All Fields] AND "decision making"[All Fields]) OR ((team[All Fields]) AND (communication[MeSH Terms]) OR (communication[All Fields])) OR (team[All Fields] AND leadership[All Fields]) AND (patient safety[MeSH Terms])

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4-8
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4-5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	n/a
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	9-10
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	9
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	9 and supplemental material
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	9-10
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	10
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	9-12
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	20
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	13-19 / 23

PRISMA 2009 Checklist

Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	20-23

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	20,26
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	22-23
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	21
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	18-19
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	18-19, 20
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	13-19
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	23
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	23
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	N/A
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	24-27
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	26-27
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	27
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	28

PRISMA 2009 Checklist

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

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