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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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3 **How effective is teamwork really? The relationship between teamwork and**
4 **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

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3 implications of teamwork. A meta-analytical approach moves beyond existing reviews on
4 teamwork in healthcare[9,15-18] and quantitatively tests if the widely advocated positive effect
5 of teamwork on performance holds true. In addition, this approach allows us to investigate
6 context variables as moderators that may influence the effect of teamwork on performance,
7 meaning that this effect might be stronger or weaker under certain conditions. Previous meta-
8 analyses[19,20] focused mainly on the effectiveness of team trainings but not on the effect of
9 teamwork itself. This meta-analysis will generate strong quantitative evidence to inform the
10 relevance of future interventions targeting teamwork in healthcare organizations.
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22 In the following we will first establish an operational definition of teamwork, elaborate on
23 relevant contextual factors, and present our respective meta-analytic results and their
24 interpretation.
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31 **Teamwork and performance**

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33 *Teamwork* as a term is widely used and often difficult to grasp. However, we absolutely
34 require a clear definition of teamwork especially for team trainings that target specific behaviors.
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36 *Teamwork* is a process that describes interactions among team members who combine collective
37 resources to resolve task demands (e.g. giving clear orders).[21,22] Teamwork or team processes
38 can be differentiated from *taskwork*. *Taskwork* denotes a team's individual interaction with tasks,
39 tools, machines and systems.[22] *Taskwork* is independent of other team members and is often
40 described as *what* a team is doing whereas *teamwork* is *how* the members of a team are doing
41 something with each other.[23] Therefore, *team performance* represents the accumulation of
42 teamwork and taskwork (i.e. what the team actually does).[17]
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3 Team performance is often described in terms of inputs, processes and outputs (IPO).[21,24-
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5 26] *Outputs* like quality of care, errors or performance are influenced by team related *processes*
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7 (i.e. teamwork) like communication, coordination or decision making. Furthermore, these
8
9 processes are influenced by various *inputs* like team members experience, task complexity, time
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11 pressure and more. This IPO framework helps to systematize the mechanisms that predict team
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13 performance and represents the basis for the selection of the teamwork studies included in our
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15 meta-analysis.
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22 **Contextual factors of teamwork effectiveness**

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24 Based on a large body of team research from various domains, we hypothesize that several
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26 contextual and methodological factors might moderate the effectiveness of teamwork, indicating
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28 that teamwork is more important under certain conditions.[27,28] Therefore, we investigate
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30 several factors: (a) team characteristics (i.e. professional composition, team familiarity, team
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32 size); (b) task type (i.e. routine vs. non-routine tasks); (c) two methodological factors related to
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34 patient realism (i.e. simulated vs. real) and the type of performance measures used (i.e. process
35
36 vs. outcome performance). In the following we discuss these potentially moderating factors and
37
38 the proposed effects on teamwork.
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42 *Professional composition.* We distinguished between interprofessional and uniprofessional
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44 teams. Interprofessional teams consist of members from various professions that must work
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46 together in a coordinated fashion.[29] Diverse educational paths in interprofessional teams may
47
48 shape respective values, beliefs, attitudes and behaviors.[30] As a result team members with
49
50 different backgrounds might perceive and interpret the environment differently and have a
51
52 different understanding of how to work together. Therefore, we assume that explicit teamwork is
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54 especially important in interprofessional teams compared to uniprofessional teams.
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3 *Team familiarity.* If team members have worked together, they are familiar with their
4 individual working styles; and roles and responsibilities are usually clear. If a team works
5 together for the first time, this potential lack of familiarity and clarity might make teamwork
6 even more important. Therefore, we differentiate between *real teams* that also work together in
7 their everyday clinical practice and *experiential teams* that only came together for study
8 purposes.
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12 *Team size.* Another factor that may moderate the relationship between teamwork and
13 performance is team size. Since larger teams exhibit more linkages among members than smaller
14 teams, they also face greater coordination challenges. Also, with increasing size teams have
15 greater difficulty developing and maintaining role structures and responsibilities. For these
16 reasons, we expect the influence of teamwork on clinical performance to be stronger in larger
17 teams as compared to smaller teams.
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21 *Task type.* Routine situations are characterized by repetitive and unvarying actions (e.g.
22 standard anaesthesia induction).[31] In contrast, non-routine situations exhibit more variation
23 and uncertainty, requiring teams to be flexible and adaptive. Whereas team members mostly rely
24 on pre-learned sequences during routine situations, during non-routine situations we assume that
25 teamwork is more important in order for team members to resolve task demands.
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29 *Patient realism.* Authors highlight the importance of using medical simulators in
30 education.[32] Therefore, we investigate the realism used in a study (simulated vs. real patients)
31 as a potential methodological factor that influences the relationship between teamwork and
32 performance. Studies conducted with medical simulators might be more standardized and less
33 influenced by confounding variables than studies conducted with real patients. Therefore, results
34 from simulation studies might show stronger relationships between the two variables. Further,
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3 using simulated patients could cause individuals and teams to act differently than in real settings,
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5 thereby distorting the results. However, in the last decade high-fidelity simulators have become
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7 increasingly realistic, suggesting that the results from simulation studies generalize to real
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9 environments. Including realism as a contextual factor in our analysis will reveal if the effects of
10
11 teamwork observed in simulation compare with real life settings. Better understanding would
12
13 provide important insights about simulation use in teamwork studies.
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17 *Performance measures.* As a second methodological factor, we expect that the type of
18
19 performance measure used in a study influences the reported teamwork effectiveness. The
20
21 literature usually differentiates between process- and outcome-related aspects of
22
23 performance.[33,34] Process performance measures are action-related aspects and refer to
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25 adequate behaviour during procedures (e.g. adhering to guidelines), making them easier to
26
27 assess. Outcome performance measures (e.g. infection rates after operations) follow team
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29 actions, with assessment occurring later than process measures. Outcome performance measures
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31 suffer from several factors: greater sensitivity to confounding variables (e.g. comorbidities),
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33 assessment challenges, and greater difficulty linking team processes to outcomes. Looking at the
34
35 predictors of the survival of cardiac arrest patients illustrates the difference between the two
36
37 types of performance measures. The main predictors for the survival (i.e. performance outcome)
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39 of a cardiac arrest patient are “*duration of the arrest*” and “*age of the patient less than 70*”.[35]
40
41 Although a team delivers perfect basic life support (i.e. high process performance) the patient
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43 can still die (i.e. low outcome performance). Due to these methodological considerations, we
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45 expect that studies assessing process performance report a stronger relationship between
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47 teamwork and performance than studies assessing outcome performance.
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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

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3 correlations were examined separately only as appropriate for sub-analyses, but an average
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5 correlation was computed for all global meta-analyses of those relationships to maintain
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7 independence.[44] All articles included in this meta-analysis are listed in Table 1 and Table 2.
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10 For the criterion level of analysis, we included only effect sizes at the team level and not on
11
12 an individual level. Therefore, the performance measure had to be clearly linked to a team. This
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14 approach aligns with research that strongly recommends against mixing levels of analysis in
15
16 meta-analytic integrations.[45,46]
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19 Two reviewers independently screened titles and abstracts from articles yielded in the search.
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21 Afterwards full texts of all relevant articles were obtained and screened by the same two
22
23 reviewers. Agreement was above 90%. Any disagreement in the selection process was resolved
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25 through consensus discussion.
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28 **Data extraction**

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30 With the help of a jointly developed coding scheme, studies were independently coded by
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32 one of the authors (JS) and another rater, both with a background in industrial psychology and
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34 human factors. 20% of the studies were rated by both coders. Inter-coder agreement was above
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36 90%. Any disagreement was resolved through discussion. The data extracted comprised details
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38 of the authors and publication as well as important study characteristics and statistical
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40 relationships between a teamwork variable and performance (Table 2).
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47 **Coding of team characteristics**

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

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

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31 *Patient realism* was either coded as “Real patients” or “Simulated patients”. “Simulated
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33 patient” included a simulated or standardized patient whereas “Real patient” included real
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35 patients in clinical settings.
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39 *Clinical performance measures* were coded either as “Outcome performance” or “Process
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41 performance”. [34,47] “Outcome performance” includes an outcome that is measured after the
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43 treatment process (e.g. infection rate, mortality). We focused only on patient-related outcomes
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45 and not on team outcomes (e.g. team satisfaction). “Process performance” describes the
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47 evaluation of the treatment process and describes how well the process was executed (e.g.
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49 adherence to guidelines through expert rating). Process performance measures are often based on
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51 official guidelines and extensive expert knowledge.[48] Thus, we assumed that process
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53 performance closely relates to patient outcomes.
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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.[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

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3	Carlson, Min,	2009	To explore the relationship	Video observation of trainees	Assessment of team	Checklist based
4	Bridges[10]		between team behaviour and	participating in a simulated	behaviour using a	expert rating
5			the delivery of an appropriate	event involving the presentation	behaviourally	
6			standard of care specific to	of acute dyspnoea	anchored rating scale	
7			the simulated case		(leadership and team	
8					behaviour	
9					measurement tool)	
10	Catchpole, Giddings,	2007	To investigate if effective	Live observation of surgical	Observation of non-	Assessment of minor
11	Wilkinson, et		teamwork can prevent the	teams conducting paediatric	technical skills using a	problems,
12	al.[69]		development of serious	cardiac and orthopaedic	behaviourally	intraoperative
13			situations and provide	surgeries	anchored rating scale	performance and
14			evidence for improvements in		(NOTECHS scoring	duration of surgery
15			training and systems		system)	
16	Catchpole, Mishra,	2008	To analyse the effects of	Observation of surgical teams	Observation of non-	Operating time and
17	Handa, et al.[70]		surgical, aesthetic, and	conducting laparoscopic	technical skills using a	errors in surgical
18			nursing teamwork skills on	cholecystectomies and carotid	behaviourally	technique
19			technical outcomes	endarterectomies	anchored rating scale	
20					(NOTECHS scoring	
21					system)	
22	Cooper,	1999	To examine the relationship	Video observation of emergency	Survey about leadership	Checklist based
23	Wakelam[71]		between leadership behaviour,	teams managing full	behaviour using the	expert rating
24			team dynamics and task	cardiopulmonary arrests with a	Leadership Behaviour	
25			performance	resuscitation attempt lasting	Description	
26				longer than 3 minutes	Questionnaire	
27	Davenport,	2007	To measure the impact of	Survey of staff on general and	Survey about teamwork	Surgical morbidity
28	Henderson,		organizational climate safety	vascular surgery services	climate, level of	Surgical mortality
29	Mosca, et al.[72]		factors on risk-adjusted		communication and	
30			surgical morbidity and		collaboration with	
31			mortality		surgeon	
32	El Bardissi,	2008	To identify patterns of	Live observation of surgical	Structured observation	Surgical technical
33	Wiegmann,		teamwork failures that would	teams conducting cardiac	of teamwork failures	errors
34	Henrickson, et		benefit from intervention in	surgery	that disrupted the flow	
35	al.[73]		the cardiac surgical setting		of the operation	
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37	Gillespie, Chaboyer,	2012	To investigate how various	Live observation of surgical	Structured observation	Deviation from
38	Fairweather[74]		human factors variables,	teams across 10 specialties	of numbers of	expected length of
39			extend the expected length of		communication	operation
40			an operation		failures	
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3	Kolbe, Burtscher,	2012	To test the relationship between	Observation of 2-person (nurse,	Structured observation	Checklist based
4	Wacker, et al.[75]		speaking up and technical	resident) ad hoc anaesthesia	of speaking up	expert rating
5			team performance in	teams performing simulated	behaviour	
6			anaesthesia.	inductions of general		
7				anaesthesia with minor		
8				nonroutine events		
9	Kuenzle, Zala-Mezo,	2009	To investigate shared leadership	Observation of 2-person (nurse,	Structured observation	Reaction time to
10	Wacker, et al.[76]		patterns during anaesthesia	resident) ad hoc anaesthesia	of leadership	nonroutine event
11			induction and to show how	teams performing simulated	behaviour	
12			they are linked to team	inductions of general		
13			performance	anaesthesia with a nonroutine		
14				event (asystole)		
15	Manojilovich,	2009	To determine the relationships	A survey was conducted with	Survey about perception	Ventilator-associated
16	Antonakos, David,		between patients' outcomes	nurses on various ICU wards	of nurse-physician	pneumonia
17	et al.[77]		and nurses' perceptions of		communication using	Bloodstream
18			communication and		the ICU-nurse	infections
19			characteristics of the practice		physician	Pressure ulcers
20			environment.		questionnaire	Acute physiology and
21						chronic health
22						evaluation score
23	Manser, Bogdanovic,	2015	To investigate surgeons team	Live observation of surgical	Structured observation	Checklist based
24	Arora, et al.[78]		management skills and its	teams managing a simulated	of team management	expert rating
25			influence on performance	laparoscopic cholecystectomy	using the ComEd-E	
26					observation system	
27	Marsch, Müller,	2004	To determine whether and how	Observation of healthcare worker	Structured observation	Checklist based
28	Marquardt, et		human factors affect the	(nurse, physician) managing a	of task distribution,	expert rating
29	al.[79]		quality of cardiopulmonary	cardiac arrest due to ventricular	information transfer	
30			resuscitation	fibrillation using a high-fidelity	and leadership	
31				patient simulator	behaviour within the	
32					team	
33	Mazzocco, Petitti,	2009	To determine if patients of	Live observation of surgical	Structured observation	Postoperative
34	Fong, et al.[80]		teams with good teamwork	teams managing a variety of	of information sharing,	complications and
35			had better outcomes than	surgical procedures	inquiry for relevant	death
36			those with poor teamwork		information and	
37					vigilance and	
38					awareness using a	
39					behaviourally	
40					anchored rating scale	
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3	Mishra, Catchpole,	2008	To report on the development	Live observation of surgical	Assessment of non-	Surgical technical
4	Dale, et al.[81]		and evaluation of a method	teams conducting laparoscopic	technical skills using a	errors assessed
5			for measuring operating-	cholecystectomy	behaviourally	with the OCHRA-
6			theatre teamwork quality		anchored rating scale	tool
7					(NOTECHS scoring	
8					system)	
9	Schmutz, Hoffmann,	2015	To investigate the moderating	Video observation of paediatric	Structured observation	Checklist based
10	Heimberg, et		effect of task characteristics	teams managing various	of closed loop	expert rating
11	al.[82]		on the relationship between	paediatric emergencies using a	communication, task	
12			coordination and performance	high-fidelity patient simulator	distribution and	
13					provide information	
14					without request using	
15					the CoMeT-E	
16					observation system	
17	Siassakos, Bristowe,	2012	To investigate the relationship	Video observation of teams	Structured observation	Timely
18	Draycott, et al.[83]		between patient satisfaction	(physicians, midwives)	of closed loop	administration of
19			and communication	managing obstetric emergencies	communication	magnesium
20				in secondary and tertiary		sulphate
21				maternity units		
22	Siassakos, Fox,	2011	To determine whether team	Video observation of healthcare	Assessment of generic	Clinical efficiency
23	Crofts, et al.[84]		performance in a simulated	professionals (physician,	teamwork using a	score
24			emergency is related to	midwives) managing various	behaviourally	
25			generic teamwork skills and	emergencies using a high-	anchored rating scale	
26			behaviors	fidelity patient simulator	(teamwork analytical	
27					tool)	
28	Thomas, Sexton,	2006	To investigate the relationship	Video observation of neonatal	Structured observation	Compliance with
29	Lasky, et al.[85]		of team behaviours during	care teams managing a	of communication,	Neonatal
30			delivery room care and	resuscitation during a caesarean	team management and	Resuscitation
31			behaviours relate to the	section	leadership	Program guidelines
32			quality of care			
33	Tschan, Semmer,	2006	To investigate the influence of	Video observation of medical	Structured observation	Clinical performance
34	Gautschi, et al.[86]		human factors on team	emergency teams (senior doctor,	of directive leadership	assessed based on a
35			performance in medical	resident, nurse) managing a	and structuring inquiry	time-based coding
36			emergency driven groups	cardiac arrest in a high-fidelity		of observable
37				patient simulator		technical acts
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3	Tschan, Semmer,	2009	To investigate the influence of	Video observation of groups of	Structured observation	Accuracy of
4	Gurtner, et al.[87]		communication on diagnostic	physicians diagnosing a difficult	of the diagnostic	diagnosis
5			accuracy in ambiguous	patient with an anaphylactic	information that have	
6			situations	shock in a high-fidelity patient	been considered,	
7				simulator	explicit reasoning and	
8					talking to the room	
9						
10	Westli, Johnsen, Eid,	2010	To investigate whether	Video observation of trauma	Assessment of non-	Checklist based
11	et al.[88]		demonstrated teamwork skills	teams (surgeons,	technical skills using a	expert rating
12			and behaviour indicating	anaesthesiologists, nurses,	behaviourally	
13			shared mental models would	radiographers) in a high-fidelity	anchored rating scale	
14			be associated with improved	patient simulator	(ANTS and ATOM	
15			medical management		scoring system)	
16	Wiegmann, El	2007	To investigate surgical errors	Live observation of surgical	Structured observation	Structured
17	Bardissi, Dearani,		and their relationship to	teams conducting cardiac	of teamwork and	observation of
18	et al.[89]		surgical flow disruptions to	surgery operations	communication	surgical errors
19			understand better the effect of		failures	during the
20			these disruptions on surgical			operation
21			errors and patient safety			
22	Williams, Lasky,	2010	To describe relationships	Video observation of intensive	Structured observation	Structured
23	Dannemiller, et		between teamwork	care teams managing neonatal	of teamwork behaviour	observation of
24	al.[90]		behaviours and errors during	resuscitations	(vigilance, workload	errors (non-
25			neonatal resuscitation		management,	compliance with
26					information sharing,	guidelines)
27					inquiry, assertion)	
28	Wright, Phillips-	2009	To test if observer ratings of	Video observation of teams	Observation using a	Checklist based
29	Bute, Petrusa, et		team skills will correlate with	consisting of medical students	behaviourally	expert rating
30	al.[91]		objective measures of clinical	performing low-fidelity	anchored rating scale	
31			performance	classroom based patient	for teamwork skills	
32				assessment and high-fidelity	(assertiveness,	
33				simulation emergent care.	decision-making,	
34					situation assessment,	
35					leadership,	
36	Yamada, Fuerch,	2016	To investigate the effect of	Video observation of teams	Structured observation	Error rate
37	Halamek[92]		standardized communication	(Neonatologists, neonatal nurse	of standardised	Time to initiate
38			techniques on errors during	practitioners, neonatology	communication	positive pressure
39			resuscitation	fellows) managing neonatal		ventilation
40				resuscitation		Time to chest
41						compression
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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

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3	Manser, Bogdanovic, Arora, et	2015	.39	Surgery	19	Interprofessional	Experimental	5	Routine	Simulated	Process
4	al.[78]										
5	Marsch, Müller, Marquardt, et	2004	.23	Intensive	16	Interprofessional	Experimental	3	Non-routine	Simulated	Process
6	al.[79]			care							
7	Mazzocco, Petitti, Fong, et al.[80]	2009	.11	Surgery	293	Interprofessional	Real	6	Routine	Real	Outcome
8											
9	Mishra, Catchpole, Dale, et	2008	.05	Surgery	26	Interprofessional	Real	6	Routine	Real	Process
10	al.[81]										
11	Schmutz, Hoffmann, Heimberg,	2015	.12	Emergency	68	Interprofessional	Real	6	Non-routine	Simulated	Process
12	et al.[82]			medicine							
13	Siassakos, Bristowe, Draycott, et	2012	.66	Obstetrics	19	Interprofessional	Real	6	Non-routine	Simulated	Process
14	al.[83]										
15	Siassakos, Fox, Crofts, et al.[84]	2011	.55	Emergency	24	Interprofessional	Experimental	6	Non-routine	Simulated	Process
16				medicine/ obstetrics							
17	Thomas, Sexton, Lasky, et al.[85]	2006	.23	Neonatal	132	Interprofessional	Real	5	Non-routine	Real	Process
18				care							
19	Tschan, Semmer, Gautschi, et	2006	.23	Emergency	21	Interprofessional	Experimental	5	Non-routine	Simulated	Process
20	al.[86]			medicine							
21	Tschan, Semmer, Gurtner, et	2009	.37	Emergency	20	Uniprofessional	Experimental	2.65	Non-routine	Simulated	Outcome
22	al.[87]			medicine							
23	Westli, Johnsen, Eid, et al.[88]	2010	.18	Emergency	27	Interprofessional	Real	5.1	Non-routine	Simulated	Process
24				medicine							
25	Wiegmann, El Bardissi, Dearani,	2007	.56	Surgery	31	Interprofessional	Real		Routine	Real	Process
26	et al.[89]										
27	Williams, Lasky, Dannemiller, et	2010	.18	Neonatal	12	Interprofessional	Real	5	Non-routine	Real	Process
28	al.[90]			care							
29	Wright, Phillips-Bute, Petrusa, et	2009	.81	General care	9	Uniprofessional	Experimental	4	Non-routine	Simulated	Process
30	al.[91]										
31	Yamada, Fuerch, Halamek[92]	2016	.11	Emergency	13	Interprofessional	Experimental	3	Non-routine	Simulated	Process
32				medicine							
33											

^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

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3 interventions we only included the sample size of the individual studies as a potential bias into
4
5 the meta-analysis.
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8 The estimation of meta-analytical models including the outlier analyses were performed
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10 with the package “metafor” from the programming language and statistical environment R.[52]
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13 14 15 **RESULTS**

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17 The online search resulted in 2002 articles (Figure 1). Based on title and abstract 67 articles
18
19 were selected for a full text review. Full text examination, forward and backward search of
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21 selected articles and relevant reviews resulted in 30 studies coming from 28 articles (Two
22
23 publications presented two independent studies in one publication[69,70]). Two additional
24
25 studies were identified via contacting authors directly and have been presented at conferences in
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27 the past.[65,78] This led to a total of 32 studies coming from 30 articles. Following suggestions
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29 by Viechtbauer and Cheung,[54] outliers were examined using the externally standardized
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31 residual score. One case (Carlson et al.,[10] $r = .89$, $n = 44$, standardized residual score = 4.26)
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33 was identified as outlier and therefore excluded from further analyses, resulting in a final sample
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35 size of $k = 31$.
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39
40 Table 1 provides a qualitative description of the selected articles including study objectives,
41
42 the setting in which the studies were carried out and a description of the teamwork processes as
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44 well as the outcome measures that were assessed. If a specific tool for the assessment of a
45
46 teamwork process or outcome measure was used this is indicated in the corresponding column.
47
48 Observational studies were most prevalent. Teamwork processes were assessed using either
49
50 behaviourally anchored rating scales ($N=8$) or structured observation ($N=19$) of specific
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52 teamwork behaviour. Structured observation—as we describe it—is defined as a purely
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3 descriptive assessment of certain behaviour usually using a predefined observation system (e.g.
4 amount of speaking up behaviour). In contrast, behaviourally anchored rating scales consist of an
5 evaluation of teamwork process behaviour by an expert. Only three studies used surveys to
6 assess teamwork behaviours. The majority of the studies ($N=27$) assessed process performance
7 using either a checklist-based expert rating or assessing a reaction time measure after the
8 occurrence of a certain event (e.g. time until intervention). Only four studies assessed outcome
9 performance measures (e.g. morbidity, mortality). Table 2 provides an overview of all variables
10 included in the meta-analysis including the effect sizes and moderator variables.
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24 **Effect of teamwork and contextual factors**

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26 Table 3 shows the relationship between teamwork and team performance. The sample-
27 sized weighted mean correlation was .28 (95% CI: .20 – .35, $z = 6.55$, $p < .001$), indicating that
28 teamwork is positively related to clinical performance. Results further indicated heterogeneous
29 effect size distributions across the included samples ($Q = 53.73$, $p < .05$, $I^2 = 45.96$), signifying
30 that the variability across the sample effect sizes was more than what would be expected from
31 sampling error alone.
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40 To test for moderator effects of the contextual factors, we conducted mixed-effects
41 models including the mentioned moderators: *professional composition*, *team familiarity*, *team*
42 *size*, *task type*, *patient realism* and *performance measures*.
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46

47 The omnibus test of moderators was not significant ($F = 0.18$, $df_1 = 6$, $df_2 = 18$, $p > .20$),
48 suggesting that the examined contextual factors did not influence the average effect of teamwork
49 on clinical performance. To provide greater detail about the role of the contextual factors, we
50 conducted separate analyses for the categorical contextual factors and report them in Table 3.
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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
<i>Team characteristics</i>							
<i>Professional composition</i>							
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
<i>Team familiarity</i>							
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							
<i>Task characteristics</i>							
<i>Task type</i>							
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
<i>Methodological factors</i>							
<i>Patient realism</i>							
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
<i>Performance measures</i>							
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

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3 isolated from other variables. Nevertheless, we still found a significant relationship between
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5 teamwork and objective patient outcomes (e.g. postoperative complications, bloodstream
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7 infections) despite the methodological challenges of measuring outcome performance and the
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9 small number of studies using outcome performance ($k = 4$).
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12 Our results are in line with previous meta-analyses investigating the effectiveness of team
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14 training in healthcare.[19,20] Similar to our results, Hughes et al. highlighted the effectiveness of
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16 team trainings under a variety of conditions—irrespective of team composition,[19] simulator
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18 fidelity or patient acuity of the trainee’s unit as well as other factors.
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21 We were unable to find a moderation of task type in our study, potentially explained by task
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23 interdependence, which reflects the degree to which team members depend on one another for
24
25 their effort, information, and resources.[56] A meta-analysis including teams from multiple
26
27 industries (e.g. project teams, management teams) found that task interdependence moderates the
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29 relationship between teamwork and performance, demonstrating the importance of teamwork for
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31 highly interdependent team tasks.[57] Most studies included in our analysis focused on rather
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33 short and intense patient care episodes (e.g. a surgery, a resuscitation task) with high task
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35 interdependence, which may explain the high relevance of teamwork for all these teams.
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42 **Limitations and future directions**

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

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

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

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

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3 up within the team.[59,60] Unfortunately we were not able to extract this information from the
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5 primary studies. Therefore, future work needs to consider and also document a broader range of
6
7 potentially influencing factors.
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12 **Conclusion**

14 The current meta-analysis confirms that teamwork across various team compositions
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16 represents a powerful process to improve patient care. Good teamwork can be achieved by joint
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18 reflection about teamwork during clinical event debriefings[61,62] as well as team trainings[63]
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20 and system improvement. All healthcare organisations should recognise these findings and place
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22 continuous efforts into maintaining and improving teamwork for the benefit of their patients.
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21
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26
27
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33

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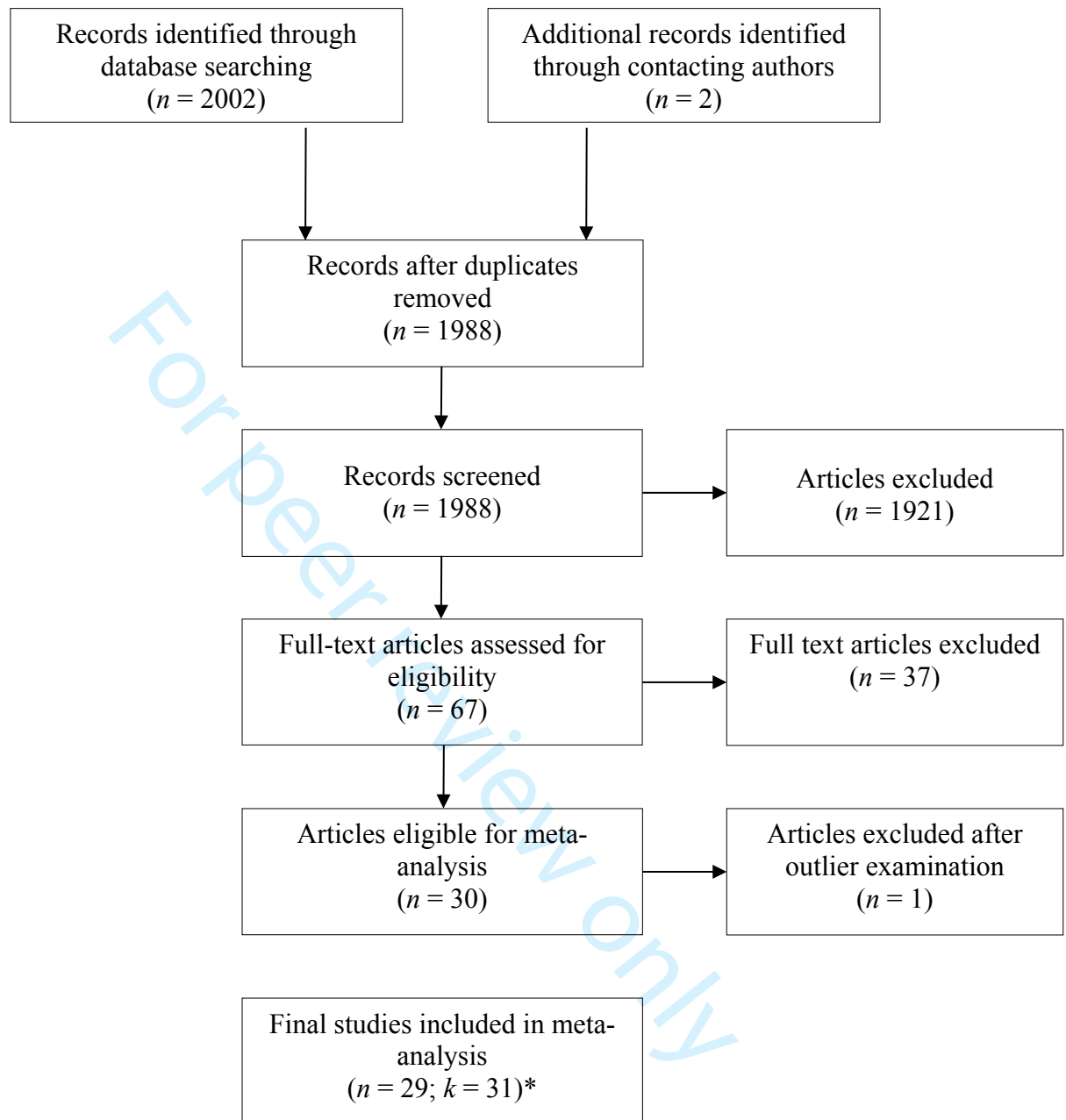
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Figure 1. Systematic literature search.



*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

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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
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Page 1 of 2

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

For more information, visit: www.prisma-statement.org.

Page 2 of 2

For peer review only

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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

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-028280.R1
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Primary Subject Heading:	Communication
Secondary Subject Heading:	Communication
Keywords:	teamwork, non-technical skills, communication, meta-analysis, teams

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Manuscripts

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

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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.

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

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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

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3 care priorities. Small sample sizes, however, increase the likelihood of reporting results that fail
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5 to represent true effect. Third, studies investigating healthcare teams often ignore important
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7 context variables of teams (e.g. team composition and size, task characteristics, team
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9 environment) that likely influence the effect that teamwork has on clinical performance.[12,13]
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12 These inconsistencies in the teamwork literature may lead to confusion about the importance
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14 of teamwork in healthcare, thus giving voice to critics who hinder efforts to improve teamwork.
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16 We aim to address these problems with a meta-analytical study investigating the performance
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18 implications of teamwork. A meta-analytical approach moves beyond existing reviews on
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20 teamwork in healthcare[8,14-17] and quantitatively tests if the widely advocated positive effect
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22 of teamwork on performance holds true. In addition, this approach allows us to investigate
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24 context variables as moderators that may influence the effect of teamwork on performance,
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26 meaning that this effect might be stronger or weaker under certain conditions. Previous meta-
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28 analyses[18,19] focused mainly on the effectiveness of team trainings but not on the effect of
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30 teamwork itself. This meta-analysis will generate quantitative evidence to inform the relevance
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32 of future interventions, regulations and policies targeting teamwork in healthcare organizations.
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37 In the following we will first establish an operational definition of teamwork, elaborate on
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39 relevant contextual factors, and present our respective meta-analytic results and their
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41 interpretation.
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47 **Teams, teamwork and team performance**

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49 In order to clearly understand the impact of teamwork on performance it is necessary to
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51 provide a brief introduction to teams, teamwork and team performance. We define teams as
52
53 identifiable social work units consisting of two or more people with several unique
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3 characteristics. These characteristics include *a)* dynamic social interaction with meaningful
4 interdependencies; *b)* shared and valued goals, *c)* a discrete lifespan, *e)* distributed expertise and
5
6 *f)* clearly assigned roles and responsibilities.[20,21] Based on this definition it becomes clear that
7
8 teams must dynamically share information and resources amongst members and coordinate their
9
10 activities in order to fulfil a certain task—in other words teams need to engage in *teamwork*.
11
12

13
14 *Teamwork* as a term is widely used and often difficult to grasp. However, we absolutely
15
16 require a clear definition of teamwork especially for team trainings that target specific
17
18 behaviours. *Teamwork* is a process that describes interactions among team members who
19
20 combine collective resources to resolve task demands (e.g. giving clear orders).[22,23]
21
22 Teamwork or team processes can be differentiated from *taskwork*. *Taskwork* denotes a team's
23
24 individual interaction with tasks, tools, machines and systems.[23] *Taskwork* is independent of
25
26 other team members and is often described as *what* a team is doing whereas *teamwork* is *how* the
27
28 members of a team are doing something with each other.[24] Therefore, *team performance*
29
30 represents the accumulation of teamwork and taskwork (i.e. what the team actually does).[25]
31
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35
36 Team performance is often described in terms of inputs, processes and outputs (IPO).[22,26-
37
38 28] *Outputs* like quality of care, errors or performance are influenced by team related *processes*
39
40 (i.e. teamwork) like communication, coordination or decision making. Furthermore, these
41
42 processes are influenced by various *inputs* like team members' experience, task complexity, time
43
44 pressure and more. The IPO framework emphasizes the critical role of team processes as the
45
46 mechanism by which team members combine their resources and abilities, shaped by the context,
47
48 to resolve team task demands. It has been the basis of other more advanced models[27-29] but
49
50 has also been criticized because of its simplicity.[30] However, it is still the most popular
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3 framework to date and helps to systematize the mechanisms that predict team performance and
4
5 represents the basis for the selection of the studies included in our meta-analysis.
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10 **Contextual factors of teamwork effectiveness**

11
12 Based on a large body of team research from various domains, we hypothesize that several
13
14 contextual and methodological factors might moderate the effectiveness of teamwork, indicating
15
16 that teamwork is more important under certain conditions.[31,32] Therefore, we investigate
17
18 several factors: (a) team characteristics (i.e. professional composition, team familiarity, team
19
20 size); (b) task type (i.e. routine vs. non-routine tasks); (c) two methodological factors related to
21
22 patient realism (i.e. simulated vs. real) and the type of performance measures used (i.e. process
23
24 vs. outcome performance). In the following we discuss these potentially moderating factors and
25
26 the proposed effects on teamwork.
27
28
29

30
31 *Professional composition.* We distinguished between interprofessional and uniprofessional
32
33 teams. Interprofessional teams consist of members from various professions that must work
34
35 together in a coordinated fashion.[33] Diverse educational paths in interprofessional teams may
36
37 shape respective values, beliefs, attitudes and behaviours.[34] As a result team members with
38
39 different backgrounds might perceive and interpret the environment differently and have a
40
41 different understanding of how to work together. Therefore, we assume that explicit teamwork is
42
43 especially important in interprofessional teams compared to uniprofessional teams.
44
45

46
47 *Team familiarity.* If team members have worked together, they are familiar with their
48
49 individual working styles; and roles and responsibilities are usually clear. If a team works
50
51 together for the first time, this potential lack of familiarity and clarity might make teamwork
52
53 even more important. Therefore, we differentiate between *real teams* that also work together in
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1
2
3 their everyday clinical practice and *experiential teams* that only came together for study
4
5 purposes.
6

7
8 *Team size.* Another factor that may moderate the relationship between teamwork and
9
10 performance is team size. Since larger teams exhibit more linkages among members than smaller
11
12 teams, they also face greater coordination challenges. Also, with increasing size teams have
13
14 greater difficulty developing and maintaining role structures and responsibilities. For these
15
16 reasons, we expect the influence of teamwork on clinical performance to be stronger in larger
17
18 teams as compared to smaller teams.
19

20
21 *Task type.* Routine situations are characterized by repetitive and unvarying actions (e.g.
22
23 standard anaesthesia induction).[35] In contrast, non-routine situations exhibit more variation
24
25 and uncertainty, requiring teams to be flexible and adaptive. Whereas team members mostly rely
26
27 on pre-learned sequences during routine situations, during non-routine situations we assume that
28
29 teamwork is more important in order for team members to resolve task demands.
30
31

32
33 *Patient realism.* Authors highlight the importance of using medical simulators in
34
35 education.[36] Therefore, we investigate the realism used in a study (simulated vs. real patients)
36
37 as a potential methodological factor that influences the relationship between teamwork and
38
39 performance. Studies conducted with medical simulators might be more standardized and less
40
41 influenced by confounding variables than studies conducted with real patients. Therefore, results
42
43 from simulation studies might show stronger relationships between the two variables. Further,
44
45 using a simulator could cause individuals and teams to act differently than in real settings,
46
47 thereby distorting the results. However, in the last decade high-fidelity simulators have become
48
49 increasingly realistic, suggesting that the results from simulation studies generalize to real
50
51 environments. Including realism as a contextual factor in our analysis will reveal if the effects of
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2
3 teamwork observed in simulation compare with real life settings. Better understanding would
4
5 provide important insights about simulation use in teamwork studies.
6

7
8 *Performance measures.* As a second methodological factor, we expect that the type of
9
10 performance measure used in a study influences the reported teamwork effectiveness. The
11
12 literature usually differentiates between process- and outcome-related aspects of
13
14 performance.[37,38] Process performance measures are action-related aspects and refer to
15
16 adequate behaviour during procedures (e.g. adhering to guidelines), making them easier to
17
18 assess. Outcome performance measures (e.g. infection rates after operations) follow team
19
20 actions, with assessment occurring later than process measures. Outcome performance measures
21
22 suffer from several factors: greater sensitivity to confounding variables (e.g. comorbidities),
23
24 assessment challenges, and greater difficulty linking team processes to outcomes. Looking at the
25
26 predictors of the survival of cardiac arrest patients illustrates the difference between the two
27
28 types of performance measures. The main predictors for the survival (i.e. performance outcome)
29
30 of a cardiac arrest patient are “*duration of the arrest*” and “*age of the patient less than 70*”. [39]
31
32 Although a team delivers perfect basic life support (i.e. high process performance) the patient
33
34 can still die (i.e. low outcome performance). Due to these methodological considerations, we
35
36 expect that studies assessing process performance report a stronger relationship between
37
38 teamwork and performance than studies assessing outcome performance.
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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

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

9
10 For the criterion level of analysis, we included only effect sizes at the team level and not on
11 an individual level. Therefore, the performance measure had to be clearly linked to a team. This
12 approach aligns with research that strongly recommends against mixing levels of analysis in
13 meta-analytic integrations.[48,49]

14
15 Two reviewers independently screened titles and abstracts from articles yielded in the search.
16 Afterwards full texts of all relevant articles were obtained and screened by the same two
17 reviewers. Agreement was above 90%. Any disagreement in the selection process was resolved
18 through consensus discussion.

19 **Data extraction**

20
21 With the help of a jointly developed coding scheme, studies were independently coded by
22 one of the authors (JS) and another rater, both with a background in industrial psychology and
23 human factors. 20% of the studies were rated by both coders. Intercoder agreement was above
24 90%. Any disagreement was resolved through discussion. The data extracted comprised details
25 of the authors and publication as well as important study characteristics and statistical
26 relationships between a teamwork variable and performance (Table 2).

27 **Coding of team characteristics**

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2
3 The *professional composition* of teams was coded either as “Interprofessional” if a team
4 consisted of members from different professions (e.g. nurses and physicians) or as
5
6 “Uniprofessional” if the members of the teams were of the same profession. *Team size* was
7
8 coded as the number of members (average number if team size varied) of the investigated teams.
9
10
11 Team familiarity was coded either as “experimental” or “real”. “Real” indicates that the team
12
13 members also worked together in their everyday clinical practice. “Experimental” means that the
14
15 teams only worked together during the study.
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21 Coding of task characteristics

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23 *Task type* was coded either as “Routine task” or “Non-routine task”. We defined “Non-
24
25 routine tasks” as unexpected events that require flexible behavior often under time-pressure (e.g.
26
27 emergency situations). “Routine tasks” describe previously planned standard procedures (e.g.
28
29 standard anesthesia induction, planned surgery).
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35 Coding of methodological factors

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37 *Patient realism* was either coded as “Real patient” or “Simulated patient”. “Simulated
38
39 patient” included a patient simulator (manikin) whereas “Real patient” included real patients in
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41 clinical settings.
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44
45 *Clinical performance measures* were coded either as “Outcome performance” or “Process
46
47 performance”. [38,50] “Outcome performance” includes an outcome that is measured after the
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49 treatment process (e.g. infection rate, mortality). We focused only on patient-related outcomes
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51 and not on team outcomes (e.g. team satisfaction). “Process performance” describes the
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53 evaluation of the treatment process and describes how well the process was executed (e.g.
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3 adherence to guidelines through expert rating). Process performance measures are often based on
4 official guidelines and extensive expert knowledge.[51] Thus, we assumed that process
5 performance closely relates to patient outcomes.
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10 **Statistical Analysis**

11
12 Different types of effect sizes (e.g. Odds ratio, F values, and r) have been reported in the
13 original studies. We therefore converted the different effect sizes to a common metric, namely r
14 using the formulas provided by Borenstein et al.[52] and Walker.[53] Moreover, some samples
15 contained effect sizes of teamwork with two or more measures of performance. Because
16 independence of the included effects sizes is required for a meta-analysis,[41,54] we used
17 Fisher's z score to average the multiple correlations from the same sample. The correlations were
18 weighted for sample size. However, in contrast to many meta-analyses in social sciences, the
19 correlations were not adjusted for measurement reliability. This is because information about the
20 measurement reliability could not be compared (Kappa vs. Cronbach Alpha) or were not
21 available at all for the majority of studies. Therefore, we report uncorrected, sample-size
22 weighted mean correlation, its 95% confidence interval (CI), and the 80% credibility interval
23 (CR). The CI reflects the accuracy of a point estimate and can be used to examine the
24 significance of the effect size estimates, whereas the CR refers to the deviation of these estimates
25 and informs us about the existence of possible moderators.
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44 Random-effects models were estimated based on two considerations.[55] First, we expected
45 study heterogeneity to be high given the different study design characteristics such as *patient*
46 *realism* ("Real patient" vs. "Simulated patient"), *task type* ("Routine task" vs. "Non-routine
47 task"), and different forms of performance measures. Second, we aimed to provide an inference
48 on the average effect in the entire population of studies from which the included studies are
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3 assumed to be a random selection of it. Therefore, random-effects models were estimated.[55]
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5 These models were calculated by the restricted maximum-likelihood estimator, an efficient and
6
7 unbiased estimator.[56] Since we included only descriptive studies and no interventions we only
8
9 included the sample size of the individual studies as a potential bias into the meta-analysis. To
10
11 rule out a potential publication bias, we tested for funnel plot asymmetry using the random-effect
12
13 version of the Egger test.[57] The results indicate that there is no asymmetry in the funnel plot (z
14
15 $= 1.79$, $p = .074$), suggesting that there is no publication bias.
16
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19 The estimation of meta-analytical models including the outlier analyses were performed
20
21 with the package “metafor” from the programming language and statistical environment R.[55]
22
23

24 **Patient and public involvement**

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26 Patients and public were not involved in this study.
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29

30 **RESULTS**

31
32 The online search resulted in 2002 articles (Figure 1). Based on title and abstract 67 articles
33
34 were selected for a full text review. Full text examination, forward and backward search of
35
36 selected articles and relevant reviews resulted in 30 studies coming from 28 articles (Two
37
38 publications presented two independent studies in one publication[58,59]). Two additional
39
40 studies were identified via contacting authors directly and have been presented at conferences in
41
42 the past.[60,61] This led to a total of 32 studies coming from 30 articles. One case (Carlson et
43
44 al.,[9] $r = .89$, $n = 44$, standardized residual score = 4.26) was identified as outlier and therefore
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46 excluded from further analyses, resulting in a final sample size of $k = 31$.
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50
51 Table 1 provides a qualitative description of the selected articles including study objectives,
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53 the setting in which the studies were carried out and a description of the teamwork processes as
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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 ($Q = 53.73$, $p < .05$, $I^2 =$

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3 45.96), signifying that the variability across the sample effect sizes was more than what would be
4
5 expected from sampling error alone.
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7
8 To test for moderator effects of the contextual factors, we conducted mixed-effects
9
10 models including the mentioned moderators: *professional composition, team familiarity, team*
11
12 *size, task type, patient realism and performance measures.*
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14
15 The omnibus test of moderators was not significant ($F = 0.18, df_1 = 6, df_2 = 18, p > .20$),
16
17 suggesting that the examined contextual factors did not influence the average effect of teamwork
18
19 on clinical performance. To provide greater detail about the role of the contextual factors, we
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21 conducted separate analyses for the categorical contextual factors and report them in Table 3.
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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.

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2
3 There is no universal measure for clinical performance because the outcome is in most cases
4 context specific. In surgery, common performance measures are surgical complications,
5 mortality or morbidity.[64] In anaesthesia, studies often use expert ratings based on checklists to
6 assess the provision of anaesthesia. Expert ratings are also the common form of performance
7 assessment in simulator settings where patient outcomes like morbidity or mortality cannot be
8 measured. Future studies need to be aware that clinical performance measures depend on the
9 clinical context and that the development of valid performance measures requires considerable
10 effort and scientific rigor. Guidelines on how to develop performance assessment tools for
11 specific clinical scenarios exist and need to be accounted for.[51,65,66] Furthermore, depending
12 on the clinical setting researchers need to evaluate what specific clinical performance measures
13 are suitable and if and how they can be linked to team processes in a meaningful way.
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28 The analysis of moderators illustrates that teamwork is related with performance under a
29 variety of conditions. Our results suggest that teams in different contexts characterised by
30 different team constellations, team size and levels of acuity of care all benefit from teamwork.
31 Therefore, clinicians and educators from all fields should strive to maintain or increase effective
32 teamwork. In recent years, there has been an upsurge in crisis resource management (CRM).[19]
33 These trainings focus on team management and implement various teamwork principles during
34 crisis situations (e.g. emergencies).[67] Our results suggest that team trainings should not only
35 focus on non-routine situations like emergencies but also on routine situations (e.g. routine
36 anaesthesia induction, routine surgery) because based on our data teamwork is equally important
37 in such situations.
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51 A closer look at methodological factors of the included studies revealed that the observed
52 relationship between teamwork and performance in simulation settings does not differ from
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3 relationships observed in real settings. Therefore, we conclude that teamwork studies conducted
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5 in simulation settings generalize to real life settings. Further, the analysis of different
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7 performance measures reveals a trend towards process performance measures being more
8
9 strongly related with teamwork than outcome performance measures. A possible explanation of
10
11 this finding relates to the difficulty of investigating outcome performance measures in a manner
12
13 isolated from other variables. Nevertheless, we still found a significant relationship between
14
15 teamwork and objective patient outcomes (e.g. postoperative complications, bloodstream
16
17 infections) despite the methodological challenges of measuring outcome performance and the
18
19 small number of studies using outcome performance ($k = 4$).
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24 Our results are in line with previous meta-analyses investigating the effectiveness of team
25
26 training in healthcare.[18,19] Similar to our results, Hughes et al. highlighted the effectiveness of
27
28 team trainings under a variety of conditions—irrespective of team composition,[18] simulator
29
30 fidelity or patient acuity of the trainee's unit as well as other factors.
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33 We were unable to find a moderation of task type in our study, potentially explained by task
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35 interdependence, which reflects the degree to which team members depend on one another for
36
37 their effort, information, and resources.[68] A meta-analysis including teams from multiple
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39 industries (e.g. project teams, management teams) found that task interdependence moderates the
40
41 relationship between teamwork and performance, demonstrating the importance of teamwork for
42
43 highly interdependent team tasks.[69] Most studies included in our analysis focused on rather
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45 short and intense patient care episodes (e.g. a surgery, a resuscitation task) with high task
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47 interdependence, which may explain the high relevance of teamwork for all these teams.
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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

1
2
3 familiarity. The extent to which team members actually worked together during prior clinical
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5 practice might predict of how effectively they perform together. However, even two people
6
7 working in the same ward might actually not have interacted much during patient care depending
8
9 on the setting. Also team climate on a ward or in a hospital may be an important predictor of how
10
11 well teams work together, especially related to sharing information or speaking up within the
12
13 team.[71,72]
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16
17 Finally, the clinical context might play a role in how team members collaborate. In different
18
19 disciplines, departments or healthcare institutions different norms and routines exist on how to
20
21 work together. Therefore study results and recommendations about teamwork need to be
22
23 interpreted in the light of the respective clinical context. There are empirical indications that a
24
25 one-size-fits-all approach might not be suitable and team training efforts cannot ignore the
26
27 clinical context, especially the routines and norms about collaboration.[73] We acknowledge that
28
29 there might be other factors surrounding healthcare teams that might potentially influence
30
31 teamwork and clinical performance. However, in this review we could only extract data that was
32
33 reported in the primary studies. Since these were limited in the healthcare contexts studied, the
34
35 results might not generalise to long-term care settings or mental health, for example. Future work
36
37 needs to consider and also document a broader range of potentially influencing factors.
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44 **Conclusion**

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

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2
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7
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10
11
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21
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23 the study design. JS drafted the paper. LM analysed the data and revised the manuscript for
24 content. TM revised the manuscript for content and language. All authors approved the final
25 version.
26
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33

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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

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3	Carlson, Min,	2009	To explore the relationship	Video observation of trainees	Assessment of team	Checklist based
4	Bridges[9]		between team behaviour and	participating in a simulated	behaviour using a	expert rating
5			the delivery of an appropriate	event involving the presentation	behaviourally	
6			standard of care specific to	of acute dyspnoea	anchored rating scale	
7			the simulated case		(leadership and team	
8					behaviour	
9					measurement tool)	
10	Catchpole, Giddings,	2007	To investigate if effective	Live observation of surgical	Observation of non-	Assessment of minor
11	Wilkinson, et		teamwork can prevent the	teams conducting paediatric	technical skills using a	problems,
12	al.[58]		development of serious	cardiac and orthopaedic	behaviourally	intraoperative
13			situations and provide	surgeries	anchored rating scale	performance and
14			evidence for improvements in		(NOTECHS scoring	duration of surgery
15			training and systems		system)	
16	Catchpole, Mishra,	2008	To analyse the effects of	Observation of surgical teams	Observation of non-	Operating time and
17	Handa, et al.[59]		surgical, aesthetic, and	conducting laparoscopic	technical skills using a	errors in surgical
18			nursing teamwork skills on	cholecystectomies and carotid	behaviourally	technique
19			technical outcomes	endarterectomies	anchored rating scale	
20					(NOTECHS scoring	
21					system)	
22	Cooper,	1999	To examine the relationship	Video observation of emergency	Survey about leadership	Checklist based
23	Wakelam[81]		between leadership behaviour,	teams managing full	behaviour using the	expert rating
24			team dynamics and task	cardiopulmonary arrests with a	Leadership Behaviour	
25			performance	resuscitation attempt lasting	Description	
26				longer than 3 minutes	Questionnaire	
27	Davenport,	2007	To measure the impact of	Survey of staff on general and	Survey about teamwork	Surgical morbidity
28	Henderson,		organizational climate safety	vascular surgery services	climate, level of	Surgical mortality
29	Mosca, et al.[82]		factors on risk-adjusted		communication and	
30			surgical morbidity and		collaboration with	
31			mortality		surgeon	
32	El Bardissi,	2008	To identify patterns of	Live observation of surgical	Structured observation	Surgical technical
33	Wiegmann,		teamwork failures that would	teams conducting cardiac	of teamwork failures	errors
34	Henrickson, et		benefit from intervention in	surgery	that disrupted the flow	
35	al.[83]		the cardiac surgical setting		of the operation	
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37	Gillespie, Chaboyer,	2012	To investigate how various	Live observation of surgical	Structured observation	Deviation from
38	Fairweather[84]		human factors variables,	teams across 10 specialties	of numbers of	expected length of
39			extend the expected length of		communication	operation
40			an operation		failures	
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3	Kolbe, Burtscher,	2012	To test the relationship between	Observation of 2-person (nurse,	Structured observation	Checklist based
4	Wacker, et al.[85]		speaking up and technical	resident) ad hoc anaesthesia	of speaking up	expert rating
5			team performance in	teams performing simulated	behaviour	
6			anaesthesia.	inductions of general		
7				anaesthesia with minor		
8				nonroutine events		
9	Kuenzle, Zala-Mezo,	2009	To investigate shared leadership	Observation of 2-person (nurse,	Structured observation	Reaction time to
10	Wacker, et al.[86]		patterns during anaesthesia	resident) ad hoc anaesthesia	of leadership	nonroutine event
11			induction and to show how	teams performing simulated	behaviour	
12			they are linked to team	inductions of general		
13			performance	anaesthesia with a nonroutine		
14				event (asystole)		
15	Manojilovich,	2009	To determine the relationships	A survey was conducted with	Survey about perception	Ventilator-associated
16	Antonakos, David,		between patients' outcomes	nurses on various ICU wards	of nurse-physician	pneumonia
17	et al.[87]		and nurses' perceptions of		communication using	Bloodstream
18			communication and		the ICU-nurse	infections
19			characteristics of the practice		physician	Pressure ulcers
20			environment.		questionnaire	Acute physiology and
21						chronic health
22						evaluation score
23	Manser, Bogdanovic,	2015	To investigate surgeons team	Live observation of surgical	Structured observation	Checklist based
24	Clack, et al. [61]		management skills and its	teams managing a simulated	of team management	expert rating
25			influence on performance	laparoscopic cholecystectomy	using the ComEd-E	
26					observation system	
27	Marsch, Müller,	2004	To determine whether and how	Observation of healthcare worker	Structured observation	Checklist based
28	Marquardt, et		human factors affect the	(nurse, physician) managing a	of task distribution,	expert rating
29	al.[88]		quality of cardiopulmonary	cardiac arrest due to ventricular	information transfer	
30			resuscitation	fibrillation using a high-fidelity	and leadership	
31				patient simulator	behaviour within the	
32					team	
33	Mazzocco, Petitti,	2009	To determine if patients of	Live observation of surgical	Structured observation	Postoperative
34	Fong, et al.[89]		teams with good teamwork	teams managing a variety of	of information sharing,	complications and
35			had better outcomes than	surgical procedures	inquiry for relevant	death
36			those with poor teamwork		information and	
37					vigilance and	
38					awareness using a	
39					behaviourally	
40					anchored rating scale	
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3	Mishra, Catchpole,	2008	To report on the development	Live observation of surgical	Assessment of non-	Surgical technical
4	Dale, et al.[90]		and evaluation of a method	teams conducting laparoscopic	technical skills using a	errors assessed
5			for measuring operating-	cholecystectomy	behaviourally	with the OCHRA-
6			theatre teamwork quality		anchored rating scale	tool
7					(NOTECHS scoring	
8					system)	
9	Schmutz, Hoffmann,	2015	To investigate the moderating	Video observation of paediatric	Structured observation	Checklist based
10	Heimberg, et		effect of task characteristics	teams managing various	of closed loop	expert rating
11	al.[91]		on the relationship between	paediatric emergencies using a	communication, task	
12			coordination and performance	high-fidelity patient simulator	distribution and	
13					provide information	
14					without request using	
15					the CoMeT-E	
16					observation system	
17	Siassakos, Bristowe,	2012	To investigate the relationship	Video observation of teams	Structured observation	Timely
18	Draycott, et al.[92]		between patient satisfaction	(physicians, midwives)	of closed loop	administration of
19			and communication	managing obstetric emergencies	communication	magnesium
20				in secondary and tertiary		sulphate
21				maternity units		
22	Siassakos, Fox,	2011	To determine whether team	Video observation of healthcare	Assessment of generic	Clinical efficiency
23	Crofts, et al.[93]		performance in a simulated	professionals (physician,	teamwork using a	score
24			emergency is related to	midwives) managing various	behaviourally	
25			generic teamwork skills and	emergencies using a high-	anchored rating scale	
26			behaviors	fidelity patient simulator	(teamwork analytical	
27					tool)	
28	Thomas, Sexton,	2006	To investigate the relationship	Video observation of neonatal	Structured observation	Compliance with
29	Lasky, et al.[94]		of team behaviours during	care teams managing a	of communication,	Neonatal
30			delivery room care and	resuscitation during a caesarean	team management and	Resuscitation
31			behaviours relate to the	section	leadership	Program guidelines
32			quality of care			
33	Tschan, Semmer,	2006	To investigate the influence of	Video observation of medical	Structured observation	Clinical performance
34	Gautschi, et al.[95]		human factors on team	emergency teams (senior doctor,	of directive leadership	assessed based on a
35			performance in medical	resident, nurse) managing a	and structuring inquiry	time-based coding
36			emergency driven groups	cardiac arrest in a high-fidelity		of observable
37				patient simulator		technical acts
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3	Tschan, Semmer,	2009	To investigate the influence of	Video observation of groups of	Structured observation	Accuracy of
4	Gurtner, et al.[96]		communication on diagnostic	physicians diagnosing a difficult	of the diagnostic	diagnosis
5			accuracy in ambiguous	patient with an anaphylactic	information that have	
6			situations	shock in a high-fidelity patient	been considered,	
7				simulator	explicit reasoning and	
8					talking to the room	
9						
10	Westli, Johnsen, Eid,	2010	To investigate whether	Video observation of trauma	Assessment of non-	Checklist based
11	et al.[97]		demonstrated teamwork skills	teams (surgeons,	technical skills using a	expert rating
12			and behaviour indicating	anaesthesiologists, nurses,	behaviourally	
13			shared mental models would	radiographers) in a high-fidelity	anchored rating scale	
14			be associated with improved	patient simulator	(ANTS and ATOM	
15			medical management		scoring system)	
16	Wiegmann, El	2007	To investigate surgical errors	Live observation of surgical	Structured observation	Structured
17	Bardissi, Dearani,		and their relationship to	teams conducting cardiac	of teamwork and	observation of
18	et al.[98]		surgical flow disruptions to	surgery operations	communication	surgical errors
19			understand better the effect of		failures	during the
20			these disruptions on surgical			operation
21			errors and patient safety			
22	Williams, Lasky,	2010	To describe relationships	Video observation of intensive	Structured observation	Structured
23	Dannemiller, et		between teamwork	care teams managing neonatal	of teamwork behaviour	observation of
24	al.[99]		behaviours and errors during	resuscitations	(vigilance, workload	errors (non-
25			neonatal resuscitation		management,	compliance with
26					information sharing,	guidelines)
27					inquiry, assertion)	
28	Wright, Phillips-	2009	To test if observer ratings of	Video observation of teams	Observation using a	Checklist based
29	Bute, Petrusa, et		team skills will correlate with	consisting of medical students	behaviourally	expert rating
30	al.[100]		objective measures of clinical	performing low-fidelity	anchored rating scale	
31			performance	classroom based patient	for teamwork skills	
32				assessment and high-fidelity	(assertiveness,	
33				simulation emergent care.	decision-making,	
34					situation assessment,	
35					leadership,	
36	Yamada, Fuerch,	2016	To investigate the effect of	Video observation of teams	Structured observation	Error rate
37	Halamek[101]		standardized communication	(Neonatologists, neonatal nurse	of standardised	Time to initiate
38			techniques on errors during	practitioners, neonatology	communication	positive pressure
39			resuscitation	fellows) managing neonatal		ventilation
40				resuscitation		Time to chest
41						compression
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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	Experimental	5	Routine	Simulated	Process
Marsch, Müller, Marquardt, et al.[88]	2004	.23	Intensive care	16	Interprofessional	Experimental	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	Experimental	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	Experimental	5	Non-routine	Simulated	Process
Tschan, Semmer, Gurtner, et al.[96]	2009	.37	Emergency medicine	20	Uniprofessional	Experimental	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	Experimental	4	Non-routine	Simulated	Process
Yamada, Fuerch, Halamek[101]	2016	.11	Emergency medicine	13	Interprofessional	Experimental	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
<i>Team characteristics</i>							
<i>Professional composition</i>							
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
<i>Team familiarity</i>							
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							
<i>Task characteristics</i>							
<i>Task type</i>							
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
<i>Methodological factors</i>							
<i>Patient realism</i>							
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
<i>Performance measures</i>							
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

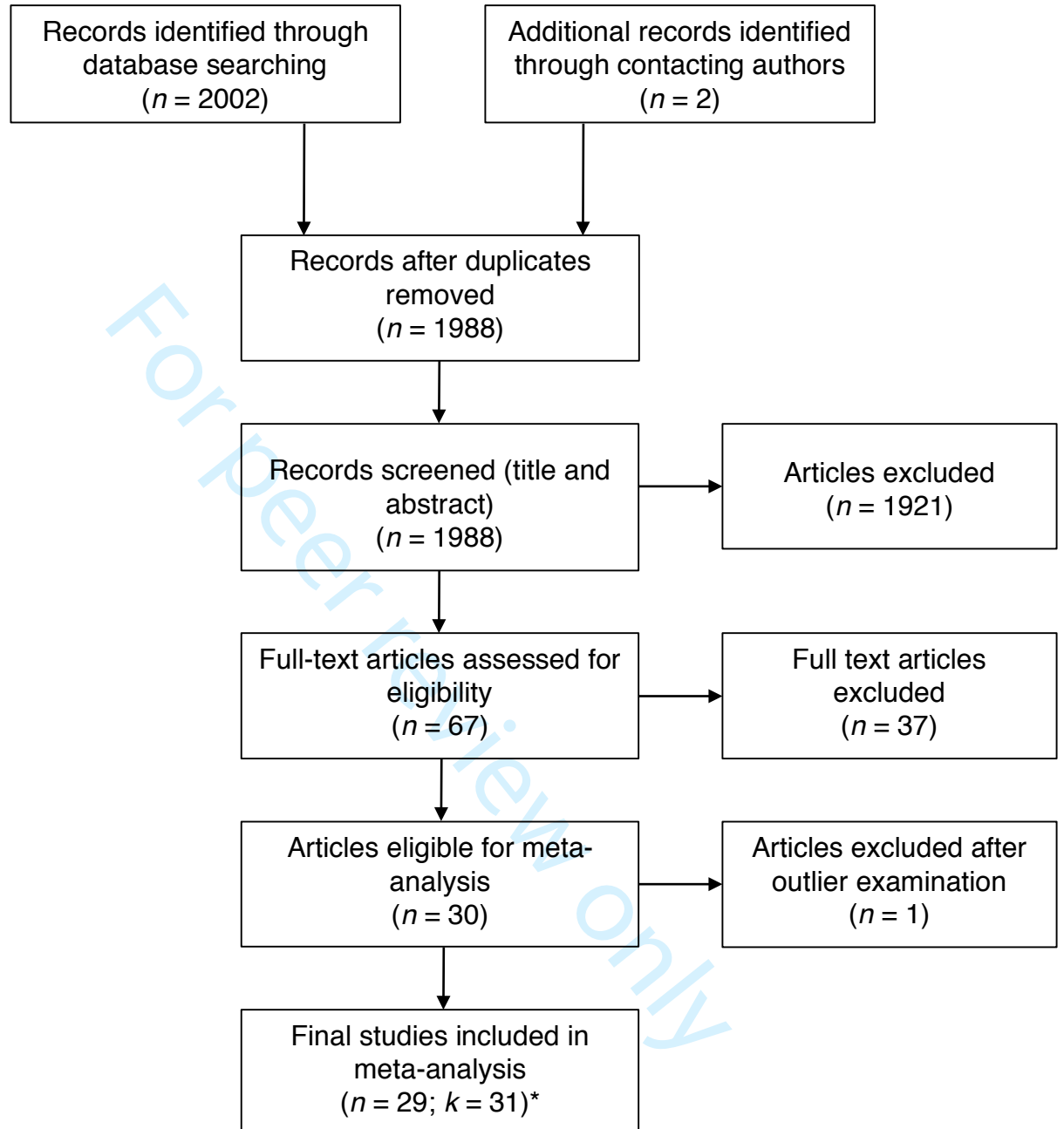
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3 **LEGENDS TO FIGURES**
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5 **Figure 1** Systematic literature search
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8 **Figure 2** Relationship between teamwork processes and performance
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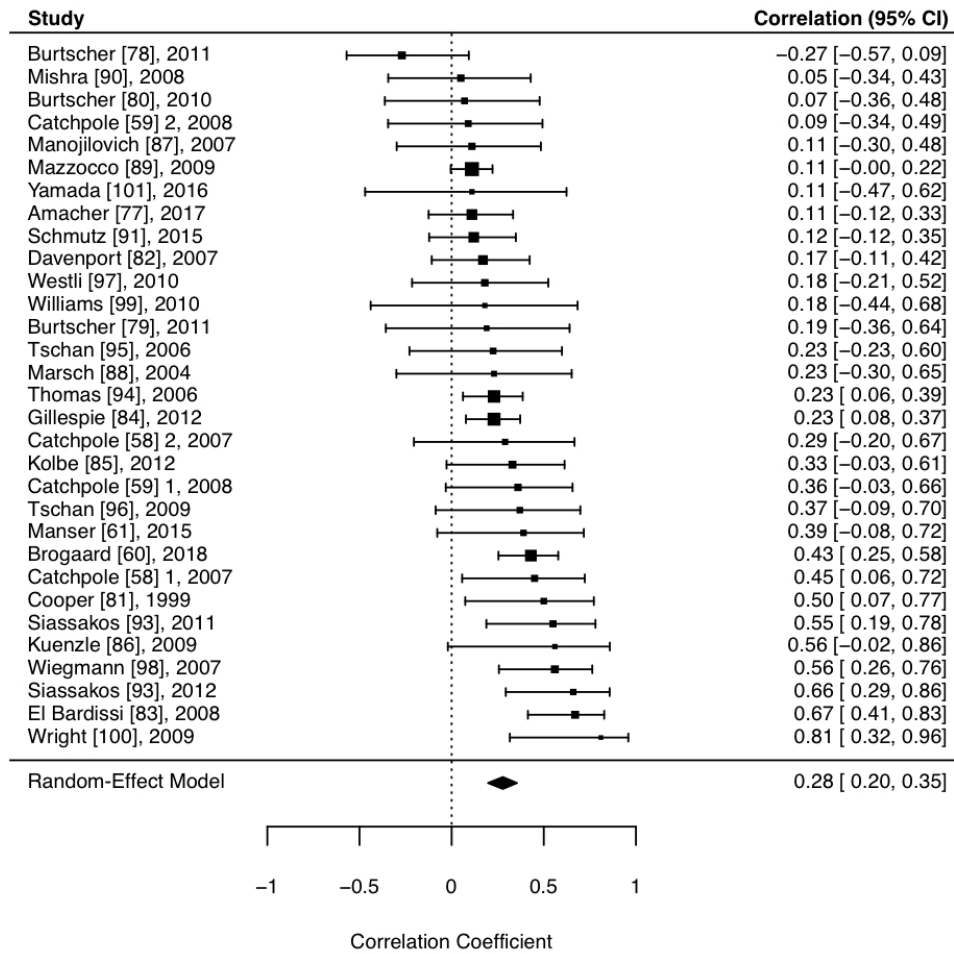


Figure 2. Relationship between teamwork processes and performance.

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

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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
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Page 1 of 2

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

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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

For more information, visit: www.prisma-statement.org.

Page 2 of 2

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

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Manuscripts

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3 **How effective is teamwork really? The relationship between teamwork and**
4 **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.

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

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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

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3 care priorities. Small sample sizes, however, increase the likelihood of reporting results that fail
4
5 to represent true effect. Third, studies investigating healthcare teams often ignore important
6
7 context variables of teams (e.g. team composition and size, task characteristics, team
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9 environment) that likely influence the effect that teamwork has on clinical performance.[12,13]
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12 These inconsistencies in the teamwork literature may lead to confusion about the importance
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14 of teamwork in healthcare, thus giving voice to critics who hinder efforts to improve teamwork.
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16 We aim to address these problems with a meta-analytical study investigating the performance
17
18 implications of teamwork. A meta-analytical approach moves beyond existing reviews on
19
20 teamwork in healthcare[8,14-17] and quantitatively tests if the widely advocated positive effect
21
22 of teamwork on performance holds true. In addition, this approach allows us to investigate
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24 context variables as moderators that may influence the effect of teamwork on performance,
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26 meaning that this effect might be stronger or weaker under certain conditions. Previous meta-
27
28 analyses[18,19] focused mainly on the effectiveness of team trainings but not on the effect of
29
30 teamwork itself. This meta-analysis will generate quantitative evidence to inform the relevance
31
32 of future interventions, regulations and policies targeting teamwork in healthcare organizations.
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37 In the following we will first establish an operational definition of teamwork, elaborate on
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39 relevant contextual factors, and present our respective meta-analytic results and their
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41 interpretation.
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47 **Teams, teamwork and team performance**

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49 In order to clearly understand the impact of teamwork on performance it is necessary to
50
51 provide a brief introduction to teams, teamwork and team performance. We define teams as
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53 identifiable social work units consisting of two or more people with several unique
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3 characteristics. These characteristics include *a)* dynamic social interaction with meaningful
4 interdependencies; *b)* shared and valued goals, *c)* a discrete lifespan, *e)* distributed expertise and
5
6 *f)* clearly assigned roles and responsibilities.[20,21] Based on this definition it becomes clear that
7
8 teams must dynamically share information and resources amongst members and coordinate their
9
10 activities in order to fulfil a certain task—in other words teams need to engage in *teamwork*.
11
12

13
14 *Teamwork* as a term is widely used and often difficult to grasp. However, we absolutely
15
16 require a clear definition of teamwork especially for team trainings that target specific
17
18 behaviours. *Teamwork* is a process that describes interactions among team members who
19
20 combine collective resources to resolve task demands (e.g. giving clear orders).[22,23]
21
22 Teamwork or team processes can be differentiated from *taskwork*. *Taskwork* denotes a team's
23
24 individual interaction with tasks, tools, machines and systems.[23] *Taskwork* is independent of
25
26 other team members and is often described as *what* a team is doing whereas *teamwork* is *how* the
27
28 members of a team are doing something with each other.[24] Therefore, *team performance*
29
30 represents the accumulation of teamwork and taskwork (i.e. what the team actually does).[25]
31
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33

34
35 Team performance is often described in terms of inputs, processes and outputs (IPO).[22,26-
36
37 28] *Outputs* like quality of care, errors or performance are influenced by team related *processes*
38
39 (i.e. teamwork) like communication, coordination or decision making. Furthermore, these
40
41 processes are influenced by various *inputs* like team members' experience, task complexity, time
42
43 pressure and more. The IPO framework emphasizes the critical role of team processes as the
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45 mechanism by which team members combine their resources and abilities, shaped by the context,
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47 to resolve team task demands. It has been the basis of other more advanced models[27-29] but
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49 has also been criticized because of its simplicity.[30] However, it is still the most popular
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2
3 framework to date and helps to systematize the mechanisms that predict team performance and
4
5 represents the basis for the selection of the studies included in our meta-analysis.
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10 **Contextual factors of teamwork effectiveness**

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12 Based on a large body of team research from various domains, we hypothesize that several
13
14 contextual and methodological factors might moderate the effectiveness of teamwork, indicating
15
16 that teamwork is more important under certain conditions.[31,32] Therefore, we investigate
17
18 several factors: (a) team characteristics (i.e. professional composition, team familiarity, team
19
20 size); (b) task type (i.e. routine vs. non-routine tasks); (c) two methodological factors related to
21
22 patient realism (i.e. simulated vs. real) and the type of performance measures used (i.e. process
23
24 vs. outcome performance). In the following we discuss these potentially moderating factors and
25
26 the proposed effects on teamwork.
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29

30
31 *Professional composition.* We distinguished between interprofessional and uniprofessional
32
33 teams. Interprofessional teams consist of members from various professions that must work
34
35 together in a coordinated fashion.[33] Diverse educational paths in interprofessional teams may
36
37 shape respective values, beliefs, attitudes and behaviours.[34] As a result team members with
38
39 different backgrounds might perceive and interpret the environment differently and have a
40
41 different understanding of how to work together. Therefore, we assume that explicit teamwork is
42
43 especially important in interprofessional teams compared to uniprofessional teams.
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46
47 *Team familiarity.* If team members have worked together, they are familiar with their
48
49 individual working styles; and roles and responsibilities are usually clear. If a team works
50
51 together for the first time, this potential lack of familiarity and clarity might make teamwork
52
53 even more important. Therefore, we differentiate between *real teams* that also work together in
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2
3 their everyday clinical practice and *experiential teams* that only came together for study
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5 purposes.
6

7
8 *Team size.* Another factor that may moderate the relationship between teamwork and
9
10 performance is team size. Since larger teams exhibit more linkages among members than smaller
11
12 teams, they also face greater coordination challenges. Also, with increasing size teams have
13
14 greater difficulty developing and maintaining role structures and responsibilities. For these
15
16 reasons, we expect the influence of teamwork on clinical performance to be stronger in larger
17
18 teams as compared to smaller teams.
19

20
21 *Task type.* Routine situations are characterized by repetitive and unvarying actions (e.g.
22
23 standard anaesthesia induction).[35] In contrast, non-routine situations exhibit more variation
24
25 and uncertainty, requiring teams to be flexible and adaptive. Whereas team members mostly rely
26
27 on pre-learned sequences during routine situations, during non-routine situations we assume that
28
29 teamwork is more important in order for team members to resolve task demands.
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32
33 *Patient realism.* Authors highlight the importance of using medical simulators in
34
35 education.[36] Therefore, we investigate the realism used in a study (simulated vs. real patients)
36
37 as a potential methodological factor that influences the relationship between teamwork and
38
39 performance. Studies conducted with medical simulators might be more standardized and less
40
41 influenced by confounding variables than studies conducted with real patients. Therefore, results
42
43 from simulation studies might show stronger relationships between the two variables. Further,
44
45 using a simulator could cause individuals and teams to act differently than in real settings,
46
47 thereby distorting the results. However, in the last decade high-fidelity simulators have become
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49 increasingly realistic, suggesting that the results from simulation studies generalize to real
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51 environments. Including realism as a contextual factor in our analysis will reveal if the effects of
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2
3 teamwork observed in simulation compare with real life settings. Better understanding would
4
5 provide important insights about simulation use in teamwork studies.
6

7
8 *Performance measures.* As a second methodological factor, we expect that the type of
9
10 performance measure used in a study influences the reported teamwork effectiveness. The
11
12 literature usually differentiates between process- and outcome-related aspects of
13
14 performance.[37,38] Process performance measures are action-related aspects and refer to
15
16 adequate behaviour during procedures (e.g. adhering to guidelines), making them easier to
17
18 assess. Outcome performance measures (e.g. infection rates after operations) follow team
19
20 actions, with assessment occurring later than process measures. Outcome performance measures
21
22 suffer from several factors: greater sensitivity to confounding variables (e.g. comorbidities),
23
24 assessment challenges, and greater difficulty linking team processes to outcomes. Looking at the
25
26 predictors of the survival of cardiac arrest patients illustrates the difference between the two
27
28 types of performance measures. The main predictors for the survival (i.e. performance outcome)
29
30 of a cardiac arrest patient are “*duration of the arrest*” and “*age of the patient less than 70*”. [39]
31
32 Although a team delivers perfect basic life support (i.e. high process performance) the patient
33
34 can still die (i.e. low outcome performance). Due to these methodological considerations, we
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36 expect that studies assessing process performance report a stronger relationship between
37
38 teamwork and performance than studies assessing outcome performance.
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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

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

11
12 For the criterion level of analysis, we included only effect sizes at the team level and not on
13 an individual level. Therefore, the performance measure had to be clearly linked to a team. This
14 approach aligns with research that strongly recommends against mixing levels of analysis in
15 meta-analytic integrations.[49,50]

16
17 Two reviewers independently screened titles and abstracts from articles yielded in the search.
18 Afterwards full texts of all relevant articles were obtained and screened by the same two
19 reviewers. Agreement was above 90%. Any disagreement in the selection process was resolved
20 through consensus discussion.

21 22 **Data extraction**

23
24 With the help of a jointly developed coding scheme, studies were independently coded by
25 one of the authors (JS) and another rater, both with a background in industrial psychology and
26 human factors. 20% of the studies were rated by both coders. Intercoder agreement was above
27 90%. Any disagreement was resolved through discussion. The data extracted comprised details
28 of the authors and publication as well as important study characteristics and statistical
29 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

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2
3 and not on team outcomes (e.g. team satisfaction). “Process performance” describes the
4 evaluation of the treatment process and describes how well the process was executed (e.g.
5 adherence to guidelines through expert rating). Process performance measures are often based on
6 official guidelines and extensive expert knowledge.[52] Thus, we assumed that process
7 performance closely relates to patient outcomes.
8
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14 **Statistical Analysis**

16
17 Different types of effect sizes (e.g. Odds ratio, F values, and r) have been reported in the
18 original studies. We therefore converted the different effect sizes to a common metric, namely r
19 using the formulas provided by Borenstein et al.[53] and Walker.[54] Moreover, some samples
20 contained effect sizes of teamwork with two or more measures of performance. Because
21 independence of the included effects sizes is required for a meta-analysis,[41,55] we used
22 Fisher’s z score to average the multiple correlations from the same sample. The correlations were
23 weighted for sample size. However, in contrast to many meta-analyses in social sciences, the
24 correlations were not adjusted for measurement reliability. This is because information about the
25 measurement reliability could not be compared (Kappa vs. Cronbach Alpha) or were not
26 available at all for the majority of studies. Therefore, we report uncorrected, sample-size
27 weighted mean correlation, its 95% confidence interval (CI), and the 80% credibility interval
28 (CR). The CI reflects the accuracy of a point estimate and can be used to examine the
29 significance of the effect size estimates, whereas the CR refers to the deviation of these estimates
30 and informs us about the existence of possible moderators.
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49 Random-effects models were estimated based on two considerations.[56] First, we expected
50 study heterogeneity to be high given the different study design characteristics such as *patient*
51 *realism* (“Real patient” vs. “Simulated patient”), *task type* (“Routine task” vs. “Non-routine
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3 task”), and different forms of performance measures. Second, we aimed to provide an inference
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5 on the average effect in the entire population of studies from which the included studies are
6
7 assumed to be a random selection of it. Therefore, random-effects models were estimated.[56]
8
9
10 These models were calculated by the restricted maximum-likelihood estimator, an efficient and
11
12 unbiased estimator.[57] Since we included only descriptive studies and no interventions we only
13
14 included the sample size of the individual studies as a potential bias into the meta-analysis. To
15
16 rule out a potential publication bias, we tested for funnel plot asymmetry using the random-effect
17
18 version of the Egger test.[58] The results indicate that there is no asymmetry in the funnel plot (z
19
20 = 1.79, $p = .074$), suggesting that there is no publication bias.
21
22

23
24 The estimation of meta-analytical models including the outlier analyses were performed
25
26 with the package “metafor” from the programming language and statistical environment R.[57]
27

28 **Patient and public involvement**

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30 Patients and public were not involved in this study.
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38 **RESULTS**

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40 The online search resulted in 2002 articles (Figure 1). Two studies were identified via
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42 contacting authors directly and have been presented at conferences in the past.[59,60] After
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44 duplicates were removed 1988 articles were screened using title and abstract. 67 articles were
45
46 then selected for a full text review. Full text examination, forward and backward search of
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48 selected articles and relevant reviews resulted in 30 studies coming from 28 articles (Two
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50 publications presented two independent studies in one publication[61,62]). This led to a total of
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52 32 studies coming from 30 articles. Following the recommendation by Viechtbauer and Cheung,
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3 [63] we screened for outliers using studentized deleted residuals. One case (Carlson et al.,[9] $r =$
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5 .89, $n = 44$, studentized deleted residuals = 4.26) was identified as outlier and therefore excluded
6
7 from further analyses, resulting in a final sample size of $k = 31$.
8
9

10 Table 1 provides a qualitative description of the selected articles including study objectives,
11 the setting in which the studies were carried out and a description of the teamwork processes as
12 well as the outcome measures that were assessed. If a specific tool for the assessment of a
13 teamwork process or outcome measure was used this is indicated in the corresponding column.
14
15 Observational studies were most prevalent. Teamwork processes were assessed using either
16 behaviourally anchored rating scales ($N=8$) or structured observation ($N=19$) of specific
17 teamwork behaviour. Structured observation—as we describe it—is defined as a purely
18 descriptive assessment of certain behaviour usually using a predefined observation system (e.g.
19 amount of speaking up behaviour). In contrast, behaviourally anchored rating scales consist of an
20 evaluation of teamwork process behaviour by an expert. Only three studies used surveys to
21 assess teamwork behaviours. The majority of the studies ($N=27$) assessed process performance
22 using either a checklist-based expert rating or assessing a reaction time measure after the
23 occurrence of a certain event (e.g. time until intervention). Only four studies assessed outcome
24 performance measures. Measures included accuracy of diagnosis, postoperative complications
25 and death, surgical morbidity and mortality, ventilator-associated pneumonia, bloodstream
26 infections, pressure ulcers and acute physiology and chronic health evaluation score. Table 2
27 provides an overview of all variables included in the meta-analysis including the effect sizes and
28 moderator variables.
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54 **Effect of teamwork and contextual factors**

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3 Table 3 and Figure 2 shows the relationship between teamwork and team performance.
4
5 The sample-sized weighted mean correlation was .28 (95% CI: .20 to .35, $z = 6.55$, $p < .001$),
6
7 indicating that teamwork is positively related to clinical performance. Results further indicated
8
9 heterogeneous effect size distributions across the included samples ($Q = 53.73$, $p < .05$, $I^2 =$
10
11 45.96), signifying that the variability across the sample effect sizes was more than what would be
12
13 expected from sampling error alone.
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16
17 To test for moderator effects of the contextual factors, we conducted mixed-effects
18
19 models including the mentioned moderators: *professional composition*, *team familiarity*, *team*
20
21 *size*, *task type*, *patient realism* and *performance measures*.
22
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24 The omnibus test of moderators was not significant ($F = 0.18$, $df_1 = 6$, $df_2 = 18$, $p > .20$),
25
26 suggesting that the examined contextual factors did not influence the average effect of teamwork
27
28 on clinical performance. To provide greater detail about the role of the contextual factors, we
29
30 conducted separate analyses for the categorical contextual factors and report them in Table 3.
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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.

1
2
3 There is no universal measure for clinical performance because the outcome is in most cases
4 context specific. In surgery, common performance measures are surgical complications,
5
6 mortality or morbidity.[66] In anaesthesia, studies often use expert ratings based on checklists to
7
8 assess the provision of anaesthesia. Expert ratings are also the common form of performance
9
10 assessment in simulator settings where patient outcomes like morbidity or mortality cannot be
11
12 measured. Future studies need to be aware that clinical performance measures depend on the
13
14 clinical context and that the development of valid performance measures requires considerable
15
16 effort and scientific rigor. Guidelines on how to develop performance assessment tools for
17
18 specific clinical scenarios exist and need to be accounted for.[52,67,68] Furthermore, depending
19
20 on the clinical setting researchers need to evaluate what specific clinical performance measures
21
22 are suitable and if and how they can be linked to team processes in a meaningful way.
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28 The analysis of moderators illustrates that teamwork is related with performance under a
29
30 variety of conditions. Our results suggest that teams in different contexts characterised by
31
32 different team constellations, team size and levels of acuity of care all benefit from teamwork.
33
34 Therefore, clinicians and educators from all fields should strive to maintain or increase effective
35
36 teamwork. In recent years, there has been an upsurge in crisis resource management (CRM).[19]
37
38 These trainings focus on team management and implement various teamwork principles during
39
40 crisis situations (e.g. emergencies).[69] Our results suggest that team trainings should not only
41
42 focus on non-routine situations like emergencies but also on routine situations (e.g. routine
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44 anaesthesia induction, routine surgery) because based on our data teamwork is equally important
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46 in such situations.
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51 A closer look at methodological factors of the included studies revealed that the observed
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53 relationship between teamwork and performance in simulation settings does not differ from
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3 relationships observed in real settings. Therefore, we conclude that teamwork studies conducted
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5 in simulation settings generalize to real life settings in acute care. Further, the analysis of
6
7 different performance measures reveals a trend towards process performance measures being
8
9 more strongly related with teamwork than outcome performance measures. A possible
10
11 explanation of this finding relates to the difficulty of investigating outcome performance
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13 measures in a manner isolated from other variables. Nevertheless, we still found a significant
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15 relationship between teamwork and objective patient outcomes (e.g. postoperative complications,
16
17 bloodstream infections) despite the methodological challenges of measuring outcome
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19 performance and the small number of studies using outcome performance ($k = 4$).
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24 Our results are in line with previous meta-analyses investigating the effectiveness of team
25
26 training in healthcare.[18,19] Similar to our results, Hughes et al. highlighted the effectiveness of
27
28 team trainings under a variety of conditions—irrespective of team composition,[18] simulator
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30 fidelity or patient acuity of the trainee's unit as well as other factors.
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33 We were unable to find a moderation of task type in our study, potentially explained by task
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35 interdependence, which reflects the degree to which team members depend on one another for
36
37 their effort, information, and resources.[70] A meta-analysis including teams from multiple
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39 industries (e.g. project teams, management teams) found that task interdependence moderates the
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41 relationship between teamwork and performance, demonstrating the importance of teamwork for
42
43 highly interdependent team tasks.[71] Most studies included in our analysis focused on rather
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45 short and intense patient care episodes (e.g. a surgery, a resuscitation task) with high task
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47 interdependence, which may explain the high relevance of teamwork for all these teams.
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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.

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3 Therefore, we encourage future studies to include outcome performance measures despite the
4 effort required.
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8 Finally, more factors may influence the relationship between teamwork and performance that
9 we were unable to extract from the studies. While we tested for the effects of team familiarity by
10 comparing experimental teams and real teams, this does not fully capture team member
11 familiarity. The extent to which team members actually worked together during prior clinical
12 practice might predict of how effectively they perform together. However, even two people
13 working in the same ward might actually not have interacted much during patient care depending
14 on the setting. Also team climate on a ward or in a hospital may be an important predictor of how
15 well teams work together, especially related to sharing information or speaking up within the
16 team.[73,74]
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28 Finally, the clinical context might play a role in how team members collaborate. In different
29 disciplines, departments or healthcare institutions different norms and routines exist on how to
30 work together. Therefore, study results and recommendations about teamwork need to be
31 interpreted in the light of the respective clinical context. There are empirical indications that a
32 one-size-fits-all approach might not be suitable and team training efforts cannot ignore the
33 clinical context, especially the routines and norms about collaboration.[75] We acknowledge that
34 there might be other factors surrounding healthcare teams that might potentially influence
35 teamwork and clinical performance. However, in this review we could only extract data that was
36 reported in the primary studies. Since these were limited in the healthcare contexts studied, the
37 results might not generalise to long-term care settings or mental health, for example. Future work
38 needs to consider and also document a broader range of potentially influencing factors.
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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.

For peer review only

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2
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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

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3	Carlson, Min,	2009	To explore the relationship	Video observation of trainees	Assessment of team	Checklist based
4	Bridges[9]		between team behaviour and	participating in a simulated	behaviour using a	expert rating
5			the delivery of an appropriate	event involving the presentation	behaviourally	
6			standard of care specific to	of acute dyspnoea	anchored rating scale	
7			the simulated case		(leadership and team	
8					behaviour	
9					measurement tool)	
10	Catchpole, Giddings,	2007	To investigate if effective	Live observation of surgical	Observation of non-	Assessment of minor
11	Wilkinson, et		teamwork can prevent the	teams conducting paediatric	technical skills using a	problems,
12	al.[61]		development of serious	cardiac and orthopaedic	behaviourally	intraoperative
13			situations and provide	surgeries	anchored rating scale	performance and
14			evidence for improvements in		(NOTECHS scoring	duration of surgery
15			training and systems		system)	
16	Catchpole, Mishra,	2008	To analyse the effects of	Observation of surgical teams	Observation of non-	Operating time and
17	Handa, et al.[62]		surgical, aesthetic, and	conducting laparoscopic	technical skills using a	errors in surgical
18			nursing teamwork skills on	cholecystectomies and carotid	behaviourally	technique
19			technical outcomes	endarterectomies	anchored rating scale	
20					(NOTECHS scoring	
21					system)	
22	Cooper,	1999	To examine the relationship	Video observation of emergency	Survey about leadership	Checklist based
23	Wakelam[83]		between leadership behaviour,	teams managing full	behaviour using the	expert rating
24			team dynamics and task	cardiopulmonary arrests with a	Leadership Behaviour	
25			performance	resuscitation attempt lasting	Description	
26				longer than 3 minutes	Questionnaire	
27	Davenport,	2007	To measure the impact of	Survey of staff on general and	Survey about teamwork	Surgical morbidity
28	Henderson,		organizational climate safety	vascular surgery services	climate, level of	Surgical mortality
29	Mosca, et al.[84]		factors on risk-adjusted		communication and	
30			surgical morbidity and		collaboration with	
31			mortality		surgeon	
32	El Bardissi,	2008	To identify patterns of	Live observation of surgical	Structured observation	Surgical technical
33	Wiegmann,		teamwork failures that would	teams conducting cardiac	of teamwork failures	errors
34	Henrickson, et		benefit from intervention in	surgery	that disrupted the flow	
35	al.[85]		the cardiac surgical setting		of the operation	
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37	Gillespie, Chaboyer,	2012	To investigate how various	Live observation of surgical	Structured observation	Deviation from
38	Fairweather[86]		human factors variables,	teams across 10 specialties	of numbers of	expected length of
39			extend the expected length of		communication	operation
40			an operation		failures	
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3	Kolbe, Burtscher,	2012	To test the relationship between	Observation of 2-person (nurse,	Structured observation	Checklist based
4	Wacker, et al.[87]		speaking up and technical	resident) ad hoc anaesthesia	of speaking up	expert rating
5			team performance in	teams performing simulated	behaviour	
6			anaesthesia.	inductions of general		
7				anaesthesia with minor		
8				nonroutine events		
9	Kuenzle, Zala-Mezo,	2009	To investigate shared leadership	Observation of 2-person (nurse,	Structured observation	Reaction time to
10	Wacker, et al.[88]		patterns during anaesthesia	resident) ad hoc anaesthesia	of leadership	nonroutine event
11			induction and to show how	teams performing simulated	behaviour	
12			they are linked to team	inductions of general		
13			performance	anaesthesia with a nonroutine		
14				event (asystole)		
15	Manojilovich,	2009	To determine the relationships	A survey was conducted with	Survey about perception	Ventilator-associated
16	Antonakos, David,		between patients' outcomes	nurses on various ICU wards	of nurse-physician	pneumonia
17	et al.[89]		and nurses' perceptions of		communication using	Bloodstream
18			communication and		the ICU-nurse	infections
19			characteristics of the practice		physician	Pressure ulcers
20			environment.		questionnaire	Acute physiology and
21						chronic health
22						evaluation score
23	Manser, Bogdanovic,	2015	To investigate surgeons team	Live observation of surgical	Structured observation	Checklist based
24	Clack, et al. [60]		management skills and its	teams managing a simulated	of team management	expert rating
25			influence on performance	laparoscopic cholecystectomy	using the ComEd-E	
26					observation system	
27	Marsch, Müller,	2004	To determine whether and how	Observation of healthcare worker	Structured observation	Checklist based
28	Marquardt, et		human factors affect the	(nurse, physician) managing a	of task distribution,	expert rating
29	al.[90]		quality of cardiopulmonary	cardiac arrest due to ventricular	information transfer	
30			resuscitation	fibrillation using a high-fidelity	and leadership	
31				patient simulator	behaviour within the	
32					team	
33	Mazzocco, Petitti,	2009	To determine if patients of	Live observation of surgical	Structured observation	Postoperative
34	Fong, et al.[91]		teams with good teamwork	teams managing a variety of	of information sharing,	complications and
35			had better outcomes than	surgical procedures	inquiry for relevant	death
36			those with poor teamwork		information and	
37					vigilance and	
38					awareness using a	
39					behaviourally	
40					anchored rating scale	
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3	Mishra, Catchpole,	2008	To report on the development	Live observation of surgical	Assessment of non-	Surgical technical
4	Dale, et al.[92]		and evaluation of a method	teams conducting laparoscopic	technical skills using a	errors assessed
5			for measuring operating-	cholecystectomy	behaviourally	with the OCHRA-
6			theatre teamwork quality		anchored rating scale	tool
7					(NOTECHS scoring	
8					system)	
9	Schmutz, Hoffmann,	2015	To investigate the moderating	Video observation of paediatric	Structured observation	Checklist based
10	Heimberg, et		effect of task characteristics	teams managing various	of closed loop	expert rating
11	al.[93]		on the relationship between	paediatric emergencies using a	communication, task	
12			coordination and performance	high-fidelity patient simulator	distribution and	
13					provide information	
14					without request using	
15					the CoMeT-E	
16					observation system	
17	Siassakos, Bristowe,	2012	To investigate the relationship	Video observation of teams	Structured observation	Timely
18	Draycott, et al.[94]		between patient satisfaction	(physicians, midwives)	of closed loop	administration of
19			and communication	managing obstetric emergencies	communication	magnesium
20				in secondary and tertiary		sulphate
21				maternity units		
22	Siassakos, Fox,	2011	To determine whether team	Video observation of healthcare	Assessment of generic	Clinical efficiency
23	Crofts, et al.[95]		performance in a simulated	professionals (physician,	teamwork using a	score
24			emergency is related to	midwives) managing various	behaviourally	
25			generic teamwork skills and	emergencies using a high-	anchored rating scale	
26			behaviors	fidelity patient simulator	(teamwork analytical	
27					tool)	
28	Thomas, Sexton,	2006	To investigate the relationship	Video observation of neonatal	Structured observation	Compliance with
29	Lasky, et al.[96]		of team behaviours during	care teams managing a	of communication,	Neonatal
30			delivery room care and	resuscitation during a caesarean	team management and	Resuscitation
31			behaviours relate to the	section	leadership	Program guidelines
32			quality of care			
33	Tschan, Semmer,	2006	To investigate the influence of	Video observation of medical	Structured observation	Clinical performance
34	Gautschi, et al.[97]		human factors on team	emergency teams (senior doctor,	of directive leadership	assessed based on a
35			performance in medical	resident, nurse) managing a	and structuring inquiry	time-based coding
36			emergency driven groups	cardiac arrest in a high-fidelity		of observable
37				patient simulator		technical acts
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3	Tschan, Semmer,	2009	To investigate the influence of	Video observation of groups of	Structured observation	Accuracy of
4	Gurtner, et al.[98]		communication on diagnostic	physicians diagnosing a difficult	of the diagnostic	diagnosis
5			accuracy in ambiguous	patient with an anaphylactic	information that have	
6			situations	shock in a high-fidelity patient	been considered,	
7				simulator	explicit reasoning and	
8					talking to the room	
9						
10	Westli, Johnsen, Eid,	2010	To investigate whether	Video observation of trauma	Assessment of non-	Checklist based
11	et al.[99]		demonstrated teamwork skills	teams (surgeons,	technical skills using a	expert rating
12			and behaviour indicating	anaesthesiologists, nurses,	behaviourally	
13			shared mental models would	radiographers) in a high-fidelity	anchored rating scale	
14			be associated with improved	patient simulator	(ANTS and ATOM	
15			medical management		scoring system)	
16	Wiegmann, El	2007	To investigate surgical errors	Live observation of surgical	Structured observation	Structured
17	Bardissi, Dearani,		and their relationship to	teams conducting cardiac	of teamwork and	observation of
18	et al.[100]		surgical flow disruptions to	surgery operations	communication	surgical errors
19			understand better the effect of		failures	during the
20			these disruptions on surgical			operation
21			errors and patient safety			
22	Williams, Lasky,	2010	To describe relationships	Video observation of intensive	Structured observation	Structured
23	Dannemiller, et		between teamwork	care teams managing neonatal	of teamwork behaviour	observation of
24	al.[101]		behaviours and errors during	resuscitations	(vigilance, workload	errors (non-
25			neonatal resuscitation		management,	compliance with
26					information sharing,	guidelines)
27					inquiry, assertion)	
28	Wright, Phillips-	2009	To test if observer ratings of	Video observation of teams	Observation using a	Checklist based
29	Bute, Petrusa, et		team skills will correlate with	consisting of medical students	behaviourally	expert rating
30	al.[102]		objective measures of clinical	performing low-fidelity	anchored rating scale	
31			performance	classroom based patient	for teamwork skills	
32				assessment and high-fidelity	(assertiveness,	
33				simulation emergent care.	decision-making,	
34					situation assessment,	
35					leadership,	
36	Yamada, Fuerch,	2016	To investigate the effect of	Video observation of teams	Structured observation	Error rate
37	Halamek[103]		standardized communication	(Neonatologists, neonatal nurse	of standardised	Time to initiate
38			techniques on errors during	practitioners, neonatology	communication	positive pressure
39			resuscitation	fellows) managing neonatal		ventilation
40				resuscitation		Time to chest
41						compression
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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

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3	Manser, Bogdanovic, Clack, et	2015	.39	Surgery	19	Interprofessional	Experimental	5	Routine	Simulated	Process
4	al.[60]										
5	Marsch, Müller, Marquardt, et	2004	.23	Intensive	16	Interprofessional	Experimental	3	Non-routine	Simulated	Process
6	al.[90]			care							
7	Mazzocco, Petitti, Fong, et al.[91]	2009	.11	Surgery	293	Interprofessional	Real	6	Routine	Real	Outcome
8											
9	Mishra, Catchpole, Dale, et	2008	.05	Surgery	26	Interprofessional	Real	6	Routine	Real	Process
10	al.[92]										
11	Schmutz, Hoffmann, Heimberg,	2015	.12	Emergency	68	Interprofessional	Real	6	Non-routine	Simulated	Process
12	et al.[93]			medicine							
13	Siassakos, Bristowe, Draycott, et	2012	.66	Obstetrics	19	Interprofessional	Real	6	Non-routine	Simulated	Process
14	al.[94]										
15	Siassakos, Fox, Crofts, et al.[95]	2011	.55	Emergency	24	Interprofessional	Experimental	6	Non-routine	Simulated	Process
16				medicine/ obstetrics							
17	Thomas, Sexton, Lasky, et al.[96]	2006	.23	Neonatal	132	Interprofessional	Real	5	Non-routine	Real	Process
18				care							
19	Tschan, Semmer, Gautschi, et	2006	.23	Emergency	21	Interprofessional	Experimental	5	Non-routine	Simulated	Process
20	al.[97]			medicine							
21	Tschan, Semmer, Gurtner, et	2009	.37	Emergency	20	Uniprofessional	Experimental	2.65	Non-routine	Simulated	Outcome
22	al.[98]			medicine							
23	Westli, Johnsen, Eid, et al.[99]	2010	.18	Emergency	27	Interprofessional	Real	5.1	Non-routine	Simulated	Process
24				medicine							
25	Wiegmann, El Bardissi, Dearani,	2007	.56	Surgery	31	Interprofessional	Real		Routine	Real	Process
26	et al.[100]										
27	Williams, Lasky, Dannemiller, et	2010	.18	Neonatal	12	Interprofessional	Real	5	Non-routine	Real	Process
28	al.[101]			care							
29	Wright, Phillips-Bute, Petrusa, et	2009	.81	General care	9	Uniprofessional	Experimental	4	Non-routine	Simulated	Process
30	al.[102]										
31	Yamada, Fuerch, Halamek[103]	2016	.11	Emergency	13	Interprofessional	Experimental	3	Non-routine	Simulated	Process
32				medicine							
33											

^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
<i>Team characteristics</i>							
<i>Professional composition</i>							
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
<i>Team familiarity</i>							
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							
<i>Task characteristics</i>							
<i>Task type</i>							
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
<i>Methodological factors</i>							
<i>Patient realism</i>							
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
<i>Performance measures</i>							
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.

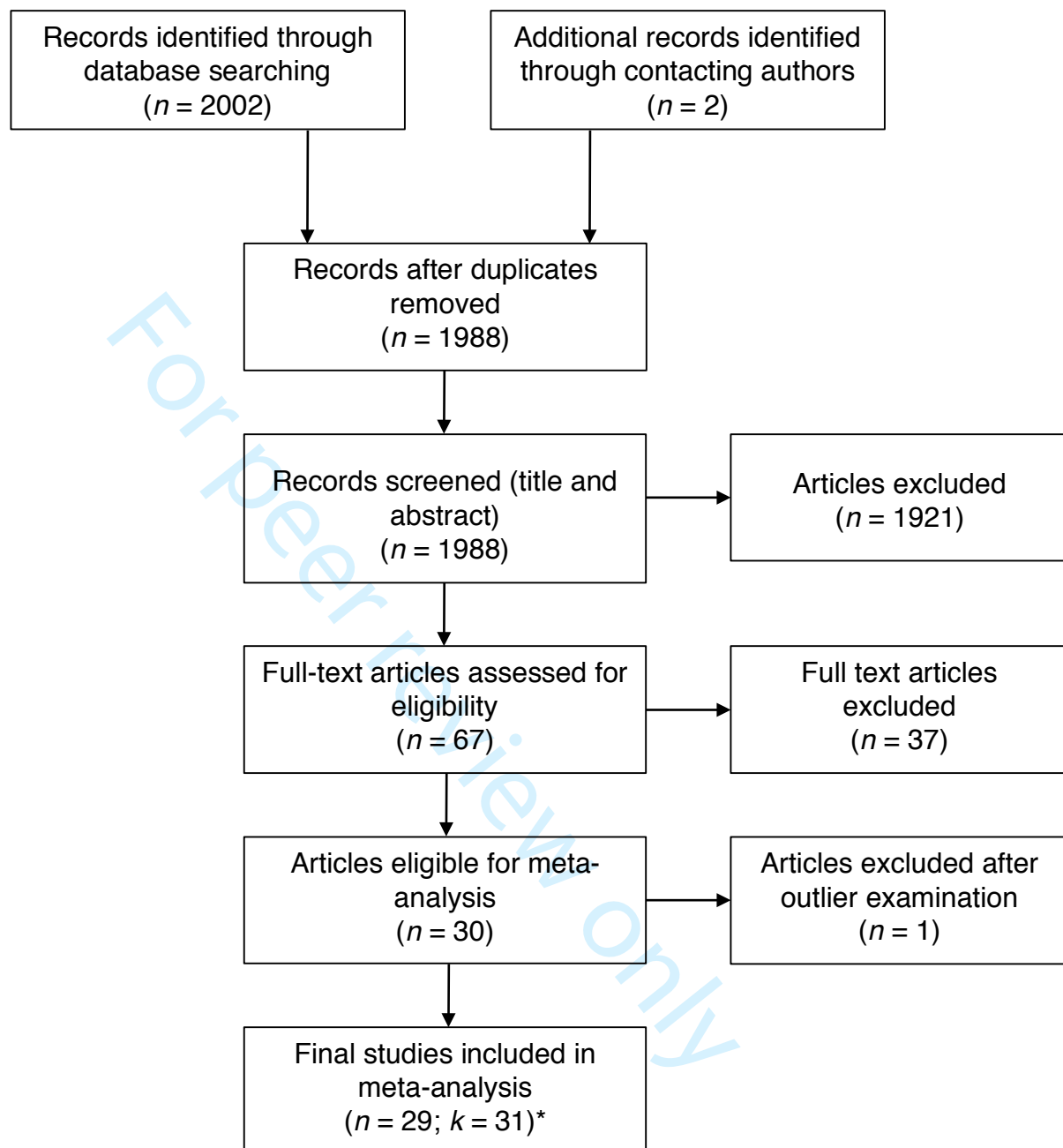
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LEGENDS TO FIGURES

Figure 1 Systematic literature search

Figure 2 Relationship between teamwork processes and performance

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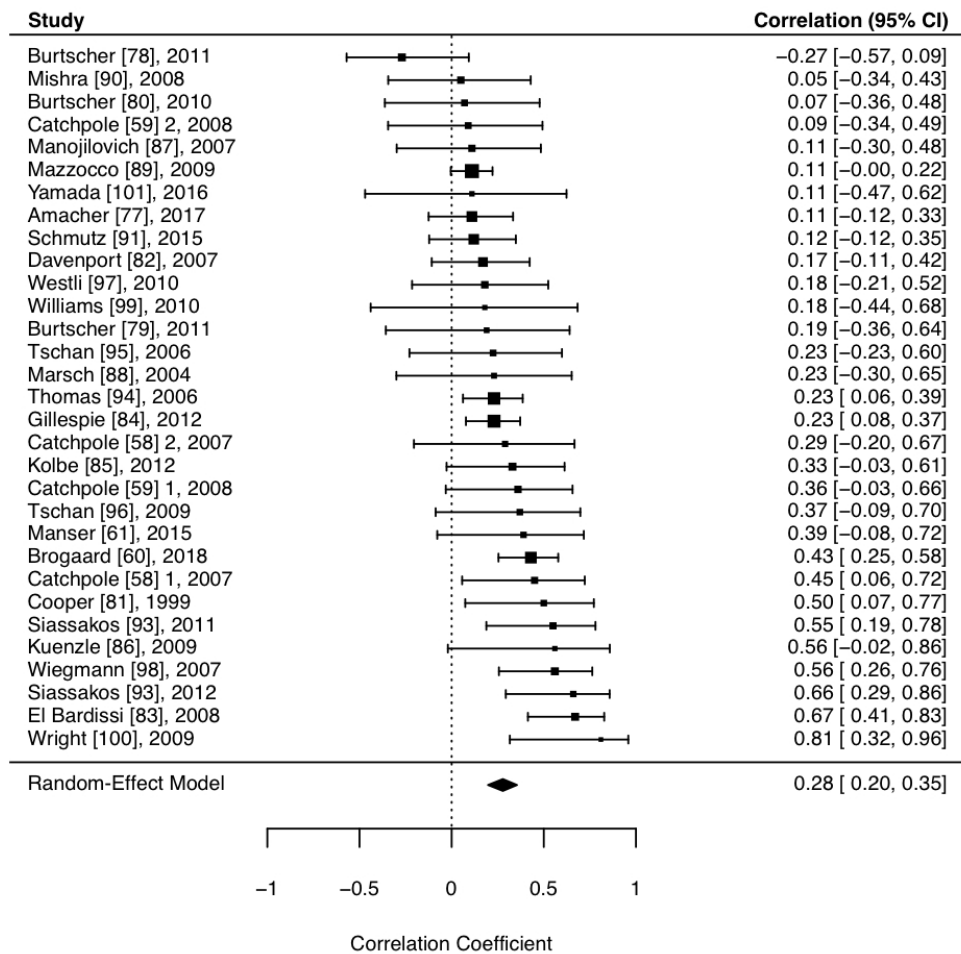


Figure 2. Relationship between teamwork processes and performance.

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
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Page 1 of 2

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

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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

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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

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-028280.R3
Article Type:	Research
Date Submitted by the Author:	14-Aug-2019
Complete List of Authors:	Schmutz, Jan B.; Northwestern University, Department of Communication Studies Meier, Laurenz ; University of Neuchâtel , Occupational Psychology and Organizations Manser, Tanja; University of Applied Sciences and Arts Northwestern Switzerland
Primary Subject Heading:	Communication
Secondary Subject Heading:	Communication
Keywords:	teamwork, non-technical skills, communication, meta-analysis, teams

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Manuscripts

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: 4852

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.

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

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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

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3 care priorities. Small sample sizes, however, increase the likelihood of reporting results that fail
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5 to represent true effect. Third, studies investigating healthcare teams often ignore important
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7 context variables of teams (e.g. team composition and size, task characteristics, team
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9 environment) that likely influence the effect that teamwork has on clinical performance.[12,13]
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12 These inconsistencies in the teamwork literature may lead to confusion about the importance
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14 of teamwork in healthcare, thus giving voice to critics who hinder efforts to improve teamwork.
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16 We aim to address these problems with a meta-analytical study investigating the performance
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18 implications of teamwork. A meta-analytical approach moves beyond existing reviews on
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20 teamwork in healthcare[8,14-17] and quantitatively tests if the widely advocated positive effect
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22 of teamwork on performance holds true. In addition, this approach allows us to investigate
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24 context variables as moderators that may influence the effect of teamwork on performance,
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26 meaning that this effect might be stronger or weaker under certain conditions. Previous meta-
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28 analyses[18,19] focused mainly on the effectiveness of team trainings but not on the effect of
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30 teamwork itself. This meta-analysis will generate quantitative evidence to inform the relevance
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32 of future interventions, regulations and policies targeting teamwork in healthcare organizations.
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37 In the following we will first establish an operational definition of teamwork, elaborate on
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39 relevant contextual factors, and present our respective meta-analytic results and their
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41 interpretation.
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47 **Teams, teamwork and team performance**

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49 In order to clearly understand the impact of teamwork on performance it is necessary to
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51 provide a brief introduction to teams, teamwork and team performance. We define teams as
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53 identifiable social work units consisting of two or more people with several unique
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3 characteristics. These characteristics include *a)* dynamic social interaction with meaningful
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5 interdependencies; *b)* shared and valued goals, *c)* a discrete lifespan, *e)* distributed expertise and
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7 *f)* clearly assigned roles and responsibilities.[20,21] Based on this definition it becomes clear that
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9 teams must dynamically share information and resources amongst members and coordinate their
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11 activities in order to fulfil a certain task—in other words teams need to engage in *teamwork*.
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14 *Teamwork* as a term is widely used and often difficult to grasp. However, we absolutely
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16 require a clear definition of teamwork especially for team trainings that target specific
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18 behaviours. *Teamwork* is a process that describes interactions among team members who
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20 combine collective resources to resolve task demands (e.g. giving clear orders).[22,23]
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22 Teamwork or team processes can be differentiated from *taskwork*. *Taskwork* denotes a team's
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24 individual interaction with tasks, tools, machines and systems.[23] *Taskwork* is independent of
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26 other team members and is often described as *what* a team is doing whereas *teamwork* is *how* the
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28 members of a team are doing something with each other.[24] Therefore, *team performance*
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30 represents the accumulation of teamwork and taskwork (i.e. what the team actually does).[25]
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35 Team performance is often described in terms of inputs, processes and outputs (IPO).[22,26-
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37 28] *Outputs* like quality of care, errors or performance are influenced by team related *processes*
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39 (i.e. teamwork) like communication, coordination or decision making. Furthermore, these
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41 processes are influenced by various *inputs* like team members' experience, task complexity, time
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43 pressure and more. The IPO framework emphasizes the critical role of team processes as the
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45 mechanism by which team members combine their resources and abilities, shaped by the context,
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47 to resolve team task demands. It has been the basis of other more advanced models[27-29] but
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49 has also been criticized because of its simplicity.[30] However, it is still the most popular
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3 framework to date and helps to systematize the mechanisms that predict team performance and
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5 represents the basis for the selection of the studies included in our meta-analysis.
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10 **Contextual factors of teamwork effectiveness**

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12 Based on a large body of team research from various domains, we hypothesize that several
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14 contextual and methodological factors might moderate the effectiveness of teamwork, indicating
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16 that teamwork is more important under certain conditions.[31,32] Therefore, we investigate
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18 several factors: (a) team characteristics (i.e. professional composition, team familiarity, team
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20 size); (b) task type (i.e. routine vs. non-routine tasks); (c) two methodological factors related to
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22 patient realism (i.e. simulated vs. real) and the type of performance measures used (i.e. process
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24 vs. outcome performance). In the following we discuss these potentially moderating factors and
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26 the proposed effects on teamwork.
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31 *Professional composition.* We distinguished between interprofessional and uniprofessional
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33 teams. Interprofessional teams consist of members from various professions that must work
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35 together in a coordinated fashion.[33] Diverse educational paths in interprofessional teams may
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37 shape respective values, beliefs, attitudes and behaviours.[34] As a result team members with
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39 different backgrounds might perceive and interpret the environment differently and have a
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41 different understanding of how to work together. Therefore, we assume that explicit teamwork is
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43 especially important in interprofessional teams compared to uniprofessional teams.
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47 *Team familiarity.* If team members have worked together, they are familiar with their
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49 individual working styles; and roles and responsibilities are usually clear. If a team works
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51 together for the first time, this potential lack of familiarity and clarity might make teamwork
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53 even more important. Therefore, we differentiate between *real teams* that also work together in
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3 their everyday clinical practice and *experiential teams* that only came together for study
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5 purposes.
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8 *Team size.* Another factor that may moderate the relationship between teamwork and
9
10 performance is team size. Since larger teams exhibit more linkages among members than smaller
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12 teams, they also face greater coordination challenges. Also, with increasing size teams have
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14 greater difficulty developing and maintaining role structures and responsibilities. For these
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16 reasons, we expect the influence of teamwork on clinical performance to be stronger in larger
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18 teams as compared to smaller teams.
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21 *Task type.* Routine situations are characterized by repetitive and unvarying actions (e.g.
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23 standard anaesthesia induction).[35] In contrast, non-routine situations exhibit more variation
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25 and uncertainty, requiring teams to be flexible and adaptive. Whereas team members mostly rely
26
27 on pre-learned sequences during routine situations, during non-routine situations we assume that
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29 teamwork is more important in order for team members to resolve task demands.
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33 *Patient realism.* Authors highlight the importance of using medical simulators in
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35 education.[36] Therefore, we investigate the realism used in a study (simulated vs. real patients)
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37 as a potential methodological factor that influences the relationship between teamwork and
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39 performance. Studies conducted with medical simulators might be more standardized and less
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41 influenced by confounding variables than studies conducted with real patients. Therefore, results
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43 from simulation studies might show stronger relationships between the two variables. Further,
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45 using a simulator could cause individuals and teams to act differently than in real settings,
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47 thereby distorting the results. However, in the last decade high-fidelity simulators have become
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49 increasingly realistic, suggesting that the results from simulation studies generalize to real
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51 environments. Including realism as a contextual factor in our analysis will reveal if the effects of
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3 teamwork observed in simulation compare with real life settings. Better understanding would
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5 provide important insights about simulation use in teamwork studies.
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8 *Performance measures.* As a second methodological factor, we expect that the type of
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10 performance measure used in a study influences the reported teamwork effectiveness. The
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12 literature usually differentiates between process- and outcome-related aspects of
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14 performance.[37,38] Process performance measures are action-related aspects and refer to
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16 adequate behaviour during procedures (e.g. adhering to guidelines), making them easier to
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18 assess. Outcome performance measures (e.g. infection rates after operations) follow team
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20 actions, with assessment occurring later than process measures. Outcome performance measures
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22 suffer from several factors: greater sensitivity to confounding variables (e.g. comorbidities),
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24 assessment challenges, and greater difficulty linking team processes to outcomes. Looking at the
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26 predictors of the survival of cardiac arrest patients illustrates the difference between the two
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28 types of performance measures. The main predictors for the survival (i.e. performance outcome)
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30 of a cardiac arrest patient are “*duration of the arrest*” and “*age of the patient less than 70*”. [39]
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32 Although a team delivers perfect basic life support (i.e. high process performance) the patient
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34 can still die (i.e. low outcome performance). Due to these methodological considerations, we
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36 expect that studies assessing process performance report a stronger relationship between
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38 teamwork and performance than studies assessing outcome performance.
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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

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

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

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

35 36 37 38 39 **Data extraction**

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42 With the help of a jointly developed coding scheme, studies were independently coded by
43 one of the authors (JS) and another rater, both with a background in industrial psychology and
44 human factors. 20% of the studies were rated by both coders. Intercoder agreement was above
45 90%. Any disagreement was resolved through discussion. The data extracted comprised details
46 of the authors and publication as well as important study characteristics and statistical
47 relationships between a teamwork variable and performance (Table 2).
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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

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3 and not on team outcomes (e.g. team satisfaction). “Process performance” describes the
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5 evaluation of the treatment process and describes how well the process was executed (e.g.
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7 adherence to guidelines through expert rating). Process performance measures are often based on
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9 official guidelines and extensive expert knowledge.[52] Thus, we assumed that process
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11 performance closely relates to patient outcomes.
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14 15 **Statistical Analysis**

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17 Different types of effect sizes (e.g. Odds ratio, F values, and r) have been reported in the
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19 original studies. We therefore converted the different effect sizes to a common metric, namely r
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21 using the formulas provided by Borenstein et al.[53] and Walker.[54] Moreover, some samples
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23 contained effect sizes of teamwork with two or more measures of performance. Because
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25 independence of the included effects sizes is required for a meta-analysis,[41,55] we used
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27 Fisher’s z score to average the multiple correlations from the same sample¹. The correlations
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29 were weighted for sample size. However, in contrast to many meta-analyses in social sciences,
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31 the correlations were not adjusted for measurement reliability. This is because information about
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33 the measurement reliability could not be compared (Kappa vs. Cronbach Alpha) or were not
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35 available at all for the majority of studies. Therefore, we report uncorrected, sample-size
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37 weighted mean correlation, its 95% confidence interval (CI), and the 80% credibility interval
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39 (CR). The CI reflects the accuracy of a point estimate and can be used to examine the
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41 significance of the effect size estimates, whereas the CR refers to the deviation of these estimates
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43 and informs us about the existence of possible moderators.
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54 ¹ Scholars have suggested to convert r to Fisher's z scores, to average the z 's, and then to backtransform it to r .
55 [56] Using simple arithmetic average (i.e., correlations will be summed and divided by the number of coefficients) is
56 problematic because the distribution of r becomes negatively skewed as the correlation is larger than zero. As a
57 result, the average r tends to underestimate the population correlation.
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3 Random-effects models were estimated based on two considerations.[57] First, we expected
4 study heterogeneity to be high given the different study design characteristics such as *patient*
5 *realism* (“Real patient” vs. “Simulated patient”), *task type* (“Routine task” vs. “Non-routine
6 task”), and different forms of performance measures. Second, we aimed to provide an inference
7 on the average effect in the entire population of studies from which the included studies are
8 assumed to be a random selection of it. Therefore, random-effects models were estimated.[57]
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10 These models were calculated by the restricted maximum-likelihood estimator, an efficient and
11 unbiased estimator.[58] Since we included only descriptive studies and no interventions we only
12 included the sample size of the individual studies as a potential bias into the meta-analysis. To
13 rule out a potential publication bias, we tested for funnel plot asymmetry using the random-effect
14 version of the Egger test.[59] The results indicate that there is no asymmetry in the funnel plot (z
15 = 1.79, $p = .074$), suggesting that there is no publication bias.
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31 The estimation of meta-analytical models including the outlier analyses were performed
32 with the package “metafor” from the programming language and statistical environment R.[58]
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35 **Patient and public involvement**

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37 Patients and public were not involved in this study.
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44 **RESULTS**

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46 The online search resulted in 2002 articles (Figure 1). Two studies were identified via
47 contacting authors directly and have been presented at conferences in the past.[60,61] After
48 duplicates were removed 1988 articles were screened using title and abstract. 67 articles were
49 then selected for a full text review. Full text examination, forward and backward search of
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3 selected articles and relevant reviews resulted in 30 studies coming from 28 articles (Two
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5 publications presented two independent studies in one publication[62,63]). This led to a total of
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7 32 studies coming from 30 articles. Following the recommendation by Viechtbauer and Cheung,
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9 [64] we screened for outliers using studentized deleted residuals. One case (Carlson et al.,[9] $r =$
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11 $.89$, $n = 44$, studentized deleted residuals = 4.26) was identified as outlier and therefore excluded
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13 from further analyses, resulting in a final sample size of $k = 31$.
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17 Table 1 provides a qualitative description of the selected articles including study objectives,
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19 the setting in which the studies were carried out and a description of the teamwork processes as
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21 well as the outcome measures that were assessed. If a specific tool for the assessment of a
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23 teamwork process or outcome measure was used this is indicated in the corresponding column.
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25 Observational studies were most prevalent. Teamwork processes were assessed using either
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27 behaviourally anchored rating scales ($N=8$) or structured observation ($N=19$) of specific
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29 teamwork behaviour. Structured observation—as we describe it—is defined as a purely
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31 descriptive assessment of certain behaviour usually using a predefined observation system (e.g.
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33 amount of speaking up behaviour). In contrast, behaviourally anchored rating scales consist of an
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35 evaluation of teamwork process behaviour by an expert. Only three studies used surveys to
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37 assess teamwork behaviours. The majority of the studies ($N=27$) assessed process performance
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39 using either a checklist-based expert rating or assessing a reaction time measure after the
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41 occurrence of a certain event (e.g. time until intervention). Only four studies assessed outcome
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43 performance measures. Measures included accuracy of diagnosis, postoperative complications
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45 and death, surgical morbidity and mortality, ventilator-associated pneumonia, bloodstream
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47 infections, pressure ulcers and acute physiology and chronic health evaluation score. Table 2
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3 provides an overview of all variables included in the meta-analysis including the effect sizes and
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5 moderator variables.
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10 **Effect of teamwork and contextual factors**

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12 Table 3 and Figure 2 shows the relationship between teamwork and team performance.
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14 The sample-sized weighted mean correlation was .28 (95% CI: .20 to .35, $z = 6.55$, $p < .001$),
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16 indicating that teamwork is positively related to clinical performance. Results further indicated
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18 heterogeneous effect size distributions across the included samples ($Q = 53.73$, $p < .05$, $I^2 =$
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20 45.96), signifying that the variability across the sample effect sizes was more than what would be
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22 expected from sampling error alone.
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26 To test for moderator effects of the contextual factors, we conducted mixed-effects
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28 models including the mentioned moderators: *professional composition*, *team familiarity*, *team*
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30 *size*, *task type*, *patient realism* and *performance measures*.
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33 The omnibus test of moderators was not significant ($F = 0.18$, $df_1 = 6$, $df_2 = 18$, $p > .20$),
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35 suggesting that the examined contextual factors did not influence the average effect of teamwork
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37 on clinical performance. To provide greater detail about the role of the contextual factors, we
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39 conducted separate analyses for the categorical contextual factors and report them in Table 3.
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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.

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3 There is no universal measure for clinical performance because the outcome is in most cases
4 context specific. In surgery, common performance measures are surgical complications,
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6 mortality or morbidity.[67] In anaesthesia, studies often use expert ratings based on checklists to
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8 assess the provision of anaesthesia. Expert ratings are also the common form of performance
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10 assessment in simulator settings where patient outcomes like morbidity or mortality cannot be
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12 measured. Future studies need to be aware that clinical performance measures depend on the
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14 clinical context and that the development of valid performance measures requires considerable
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16 effort and scientific rigor. Guidelines on how to develop performance assessment tools for
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18 specific clinical scenarios exist and need to be accounted for.[52,68,69] Furthermore, depending
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20 on the clinical setting researchers need to evaluate what specific clinical performance measures
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22 are suitable and if and how they can be linked to team processes in a meaningful way.
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28 The analysis of moderators illustrates that teamwork is related with performance under a
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30 variety of conditions. Our results suggest that teams in different contexts characterised by
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32 different team constellations, team size and levels of acuity of care all benefit from teamwork.
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34 Therefore, clinicians and educators from all fields should strive to maintain or increase effective
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36 teamwork. In recent years, there has been an upsurge in crisis resource management (CRM).[19]
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38 These trainings focus on team management and implement various teamwork principles during
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40 crisis situations (e.g. emergencies).[70] Our results suggest that team trainings should not only
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42 focus on non-routine situations like emergencies but also on routine situations (e.g. routine
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44 anaesthesia induction, routine surgery) because based on our data teamwork is equally important
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46 in such situations.
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51 A closer look at methodological factors of the included studies revealed that the observed
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53 relationship between teamwork and performance in simulation settings does not differ from
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3 relationships observed in real settings. Therefore, we conclude that teamwork studies conducted
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5 in simulation settings generalize to real life settings in acute care. Further, the analysis of
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7 different performance measures reveals a trend towards process performance measures being
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9 more strongly related with teamwork than outcome performance measures. A possible
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11 explanation of this finding relates to the difficulty of investigating outcome performance
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13 measures in a manner isolated from other variables. Nevertheless, we still found a significant
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15 relationship between teamwork and objective patient outcomes (e.g. postoperative complications,
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17 bloodstream infections) despite the methodological challenges of measuring outcome
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19 performance and the small number of studies using outcome performance ($k = 4$).
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24 Our results are in line with previous meta-analyses investigating the effectiveness of team
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26 training in healthcare.[18,19] Similar to our results, Hughes et al. highlighted the effectiveness of
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28 team trainings under a variety of conditions—irrespective of team composition,[18] simulator
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30 fidelity or patient acuity of the trainee's unit as well as other factors.
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33 We were unable to find a moderation of task type in our study, potentially explained by task
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35 interdependence, which reflects the degree to which team members depend on one another for
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37 their effort, information, and resources.[71] A meta-analysis including teams from multiple
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39 industries (e.g. project teams, management teams) found that task interdependence moderates the
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41 relationship between teamwork and performance, demonstrating the importance of teamwork for
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43 highly interdependent team tasks.[72] Most studies included in our analysis focused on rather
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45 short and intense patient care episodes (e.g. a surgery, a resuscitation task) with high task
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47 interdependence, which may explain the high relevance of teamwork for all these teams.
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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.

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3 Therefore, we encourage future studies to include outcome performance measures despite the
4
5 effort required.
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7
8 Finally, more factors may influence the relationship between teamwork and performance that
9
10 we were unable to extract from the studies. While we tested for the effects of team familiarity by
11
12 comparing experimental teams and real teams, this does not fully capture team member
13
14 familiarity. The extent to which team members actually worked together during prior clinical
15
16 practice might predict of how effectively they perform together. However, even two people
17
18 working in the same ward might actually not have interacted much during patient care depending
19
20 on the setting. Also team climate on a ward or in a hospital may be an important predictor of how
21
22 well teams work together, especially related to sharing information or speaking up within the
23
24 team.[74,75]
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27
28 Finally, the clinical context might play a role in how team members collaborate. In different
29
30 disciplines, departments or healthcare institutions different norms and routines exist on how to
31
32 work together. Therefore, study results and recommendations about teamwork need to be
33
34 interpreted in the light of the respective clinical context. There are empirical indications that a
35
36 one-size-fits-all approach might not be suitable and team training efforts cannot ignore the
37
38 clinical context, especially the routines and norms about collaboration.[76] We acknowledge that
39
40 there might be other factors surrounding healthcare teams that might potentially influence
41
42 teamwork and clinical performance. However, in this review we could only extract data that was
43
44 reported in the primary studies. Since these were limited in the healthcare contexts studied, the
45
46 results might not generalise to long-term care settings or mental health, for example. Future work
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48 needs to consider and also document a broader range of potentially influencing factors.
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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

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3	Carlson, Min,	2009	To explore the relationship	Video observation of trainees	Assessment of team	Checklist based
4	Bridges[9]		between team behaviour and	participating in a simulated	behaviour using a	expert rating
5			the delivery of an appropriate	event involving the presentation	behaviourally	
6			standard of care specific to	of acute dyspnoea	anchored rating scale	
7			the simulated case		(leadership and team	
8					behaviour	
9					measurement tool)	
10	Catchpole, Giddings,	2007	To investigate if effective	Live observation of surgical	Observation of non-	Assessment of minor
11	Wilkinson, et		teamwork can prevent the	teams conducting paediatric	technical skills using a	problems,
12	al.[62]		development of serious	cardiac and orthopaedic	behaviourally	intraoperative
13			situations and provide	surgeries	anchored rating scale	performance and
14			evidence for improvements in		(NOTECHS scoring	duration of surgery
15			training and systems		system)	
16	Catchpole, Mishra,	2008	To analyse the effects of	Observation of surgical teams	Observation of non-	Operating time and
17	Handa, et al.[63]		surgical, aesthetic, and	conducting laparoscopic	technical skills using a	errors in surgical
18			nursing teamwork skills on	cholecystectomies and carotid	behaviourally	technique
19			technical outcomes	endarterectomies	anchored rating scale	
20					(NOTECHS scoring	
21					system)	
22	Cooper,	1999	To examine the relationship	Video observation of emergency	Survey about leadership	Checklist based
23	Wakelam[84]		between leadership behaviour,	teams managing full	behaviour using the	expert rating
24			team dynamics and task	cardiopulmonary arrests with a	Leadership Behaviour	
25			performance	resuscitation attempt lasting	Description	
26				longer than 3 minutes	Questionnaire	
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28	Davenport,	2007	To measure the impact of	Survey of staff on general and	Survey about teamwork	Surgical morbidity
29	Henderson,		organizational climate safety	vascular surgery services	climate, level of	Surgical mortality
30	Mosca, et al.[85]		factors on risk-adjusted		communication and	
31			surgical morbidity and		collaboration with	
32			mortality		surgeon	
33	El Bardissi,	2008	To identify patterns of	Live observation of surgical	Structured observation	Surgical technical
34	Wiegmann,		teamwork failures that would	teams conducting cardiac	of teamwork failures	errors
35	Henrickson, et		benefit from intervention in	surgery	that disrupted the flow	
36	al.[86]		the cardiac surgical setting		of the operation	
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38	Gillespie, Chaboyer,	2012	To investigate how various	Live observation of surgical	Structured observation	Deviation from
39	Fairweather[87]		human factors variables,	teams across 10 specialties	of numbers of	expected length of
40			extend the expected length of		communication	operation
41			an operation		failures	
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3	Kolbe, Burtscher,	2012	To test the relationship between	Observation of 2-person (nurse,	Structured observation	Checklist based
4	Wacker, et al.[88]		speaking up and technical	resident) ad hoc anaesthesia	of speaking up	expert rating
5			team performance in	teams performing simulated	behaviour	
6			anaesthesia.	inductions of general		
7				anaesthesia with minor		
8				nonroutine events		
9	Kuenzle, Zala-Mezo,	2009	To investigate shared leadership	Observation of 2-person (nurse,	Structured observation	Reaction time to
10	Wacker, et al.[89]		patterns during anaesthesia	resident) ad hoc anaesthesia	of leadership	nonroutine event
11			induction and to show how	teams performing simulated	behaviour	
12			they are linked to team	inductions of general		
13			performance	anaesthesia with a nonroutine		
14				event (asystole)		
15	Manojilovich,	2009	To determine the relationships	A survey was conducted with	Survey about perception	Ventilator-associated
16	Antonakos, David,		between patients' outcomes	nurses on various ICU wards	of nurse-physician	pneumonia
17	et al.[90]		and nurses' perceptions of		communication using	Bloodstream
18			communication and		the ICU-nurse	infections
19			characteristics of the practice		physician	Pressure ulcers
20			environment.		questionnaire	Acute physiology and
21						chronic health
22						evaluation score
23	Manser, Bogdanovic,	2015	To investigate surgeons team	Live observation of surgical	Structured observation	Checklist based
24	Clack, et al. [61]		management skills and its	teams managing a simulated	of team management	expert rating
25			influence on performance	laparoscopic cholecystectomy	using the ComEd-E	
26					observation system	
27	Marsch, Müller,	2004	To determine whether and how	Observation of healthcare worker	Structured observation	Checklist based
28	Marquardt, et		human factors affect the	(nurse, physician) managing a	of task distribution,	expert rating
29	al.[91]		quality of cardiopulmonary	cardiac arrest due to ventricular	information transfer	
30			resuscitation	fibrillation using a high-fidelity	and leadership	
31				patient simulator	behaviour within the	
32					team	
33	Mazzocco, Petitti,	2009	To determine if patients of	Live observation of surgical	Structured observation	Postoperative
34	Fong, et al.[92]		teams with good teamwork	teams managing a variety of	of information sharing,	complications and
35			had better outcomes than	surgical procedures	inquiry for relevant	death
36			those with poor teamwork		information and	
37					vigilance and	
38					awareness using a	
39					behaviourally	
40					anchored rating scale	
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3	Mishra, Catchpole,	2008	To report on the development	Live observation of surgical	Assessment of non-	Surgical technical
4	Dale, et al.[93]		and evaluation of a method	teams conducting laparoscopic	technical skills using a	errors assessed
5			for measuring operating-	cholecystectomy	behaviourally	with the OCHRA-
6			theatre teamwork quality		anchored rating scale	tool
7					(NOTECHS scoring	
8					system)	
9	Schmutz, Hoffmann,	2015	To investigate the moderating	Video observation of paediatric	Structured observation	Checklist based
10	Heimberg, et		effect of task characteristics	teams managing various	of closed loop	expert rating
11	al.[94]		on the relationship between	paediatric emergencies using a	communication, task	
12			coordination and performance	high-fidelity patient simulator	distribution and	
13					provide information	
14					without request using	
15					the CoMeT-E	
16					observation system	
17	Siassakos, Bristowe,	2012	To investigate the relationship	Video observation of teams	Structured observation	Timely
18	Draycott, et al.[95]		between patient satisfaction	(physicians, midwives)	of closed loop	administration of
19			and communication	managing obstetric emergencies	communication	magnesium
20				in secondary and tertiary		sulphate
21				maternity units		
22	Siassakos, Fox,	2011	To determine whether team	Video observation of healthcare	Assessment of generic	Clinical efficiency
23	Crofts, et al.[96]		performance in a simulated	professionals (physician,	teamwork using a	score
24			emergency is related to	midwives) managing various	behaviourally	
25			generic teamwork skills and	emergencies using a high-	anchored rating scale	
26			behaviors	fidelity patient simulator	(teamwork analytical	
27					tool)	
28	Thomas, Sexton,	2006	To investigate the relationship	Video observation of neonatal	Structured observation	Compliance with
29	Lasky, et al.[97]		of team behaviours during	care teams managing a	of communication,	Neonatal
30			delivery room care and	resuscitation during a caesarean	team management and	Resuscitation
31			behaviours relate to the	section	leadership	Program guidelines
32			quality of care			
33	Tschan, Semmer,	2006	To investigate the influence of	Video observation of medical	Structured observation	Clinical performance
34	Gautschi, et al.[98]		human factors on team	emergency teams (senior doctor,	of directive leadership	assessed based on a
35			performance in medical	resident, nurse) managing a	and structuring inquiry	time-based coding
36			emergency driven groups	cardiac arrest in a high-fidelity		of observable
37				patient simulator		technical acts
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3	Tschan, Semmer,	2009	To investigate the influence of	Video observation of groups of	Structured observation	Accuracy of
4	Gurtner, et al.[99]		communication on diagnostic	physicians diagnosing a difficult	of the diagnostic	diagnosis
5			accuracy in ambiguous	patient with an anaphylactic	information that have	
6			situations	shock in a high-fidelity patient	been considered,	
7				simulator	explicit reasoning and	
8					talking to the room	
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10	Westli, Johnsen, Eid,	2010	To investigate whether	Video observation of trauma	Assessment of non-	Checklist based
11	et al.[100]		demonstrated teamwork skills	teams (surgeons,	technical skills using a	expert rating
12			and behaviour indicating	anaesthesiologists, nurses,	behaviourally	
13			shared mental models would	radiographers) in a high-fidelity	anchored rating scale	
14			be associated with improved	patient simulator	(ANTS and ATOM	
15			medical management		scoring system)	
16	Wiegmann, El	2007	To investigate surgical errors	Live observation of surgical	Structured observation	Structured
17	Bardissi, Dearani,		and their relationship to	teams conducting cardiac	of teamwork and	observation of
18	et al.[101]		surgical flow disruptions to	surgery operations	communication	surgical errors
19			understand better the effect of		failures	during the
20			these disruptions on surgical			operation
21			errors and patient safety			
22	Williams, Lasky,	2010	To describe relationships	Video observation of intensive	Structured observation	Structured
23	Dannemiller, et		between teamwork	care teams managing neonatal	of teamwork behaviour	observation of
24	al.[102]		behaviours and errors during	resuscitations	(vigilance, workload	errors (non-
25			neonatal resuscitation		management,	compliance with
26					information sharing,	guidelines)
27					inquiry, assertion)	
28	Wright, Phillips-	2009	To test if observer ratings of	Video observation of teams	Observation using a	Checklist based
29	Bute, Petrusa, et		team skills will correlate with	consisting of medical students	behaviourally	expert rating
30	al.[103]		objective measures of clinical	performing low-fidelity	anchored rating scale	
31			performance	classroom based patient	for teamwork skills	
32				assessment and high-fidelity	(assertiveness,	
33				simulation emergent care.	decision-making,	
34					situation assessment,	
35					leadership,	
36	Yamada, Fuerch,	2016	To investigate the effect of	Video observation of teams	Structured observation	Error rate
37	Halamek[104]		standardized communication	(Neonatologists, neonatal nurse	of standardised	Time to initiate
38			techniques on errors during	practitioners, neonatology	communication	positive pressure
39			resuscitation	fellows) managing neonatal		ventilation
40				resuscitation		Time to chest
41						compression
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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

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3	Manser, Bogdanovic, Clack, et	2015	.39	Surgery	19	Interprofessional	Experimental	5	Routine	Simulated	Process
4	al.[61]										
5	Marsch, Müller, Marquardt, et	2004	.23	Intensive	16	Interprofessional	Experimental	3	Non-routine	Simulated	Process
6	al.[91]			care							
7	Mazzocco, Petitti, Fong, et al.[92]	2009	.11	Surgery	293	Interprofessional	Real	6	Routine	Real	Outcome
8											
9	Mishra, Catchpole, Dale, et	2008	.05	Surgery	26	Interprofessional	Real	6	Routine	Real	Process
10	al.[93]										
11	Schmutz, Hoffmann, Heimberg,	2015	.12	Emergency	68	Interprofessional	Real	6	Non-routine	Simulated	Process
12	et al.[94]			medicine							
13	Siassakos, Bristowe, Draycott, et	2012	.66	Obstetrics	19	Interprofessional	Real	6	Non-routine	Simulated	Process
14	al.[95]										
15	Siassakos, Fox, Crofts, et al.[96]	2011	.55	Emergency	24	Interprofessional	Experimental	6	Non-routine	Simulated	Process
16				medicine/ obstetrics							
17	Thomas, Sexton, Lasky, et al.[97]	2006	.23	Neonatal	132	Interprofessional	Real	5	Non-routine	Real	Process
18				care							
19	Tschan, Semmer, Gautschi, et	2006	.23	Emergency	21	Interprofessional	Experimental	5	Non-routine	Simulated	Process
20	al.[98]			medicine							
21	Tschan, Semmer, Gurtner, et	2009	.37	Emergency	20	Uniprofessional	Experimental	2.65	Non-routine	Simulated	Outcome
22	al.[99]			medicine							
23	Westli, Johnsen, Eid, et al.[100]	2010	.18	Emergency	27	Interprofessional	Real	5.1	Non-routine	Simulated	Process
24				medicine							
25	Wiegmann, El Bardissi, Dearani,	2007	.56	Surgery	31	Interprofessional	Real		Routine	Real	Process
26	et al.[101]										
27	Williams, Lasky, Dannemiller, et	2010	.18	Neonatal	12	Interprofessional	Real	5	Non-routine	Real	Process
28	al.[102]			care							
29	Wright, Phillips-Bute, Petrusa, et	2009	.81	General care	9	Uniprofessional	Experimental	4	Non-routine	Simulated	Process
30	al.[103]										
31	Yamada, Fuerch, Halamek[104]	2016	.11	Emergency	13	Interprofessional	Experimental	3	Non-routine	Simulated	Process
32				medicine							
33											

^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
<i>Team characteristics</i>							
<i>Professional composition</i>							
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
<i>Team familiarity</i>							
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							
<i>Task characteristics</i>							
<i>Task type</i>							
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
<i>Methodological factors</i>							
<i>Patient realism</i>							
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
<i>Performance measures</i>							
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.

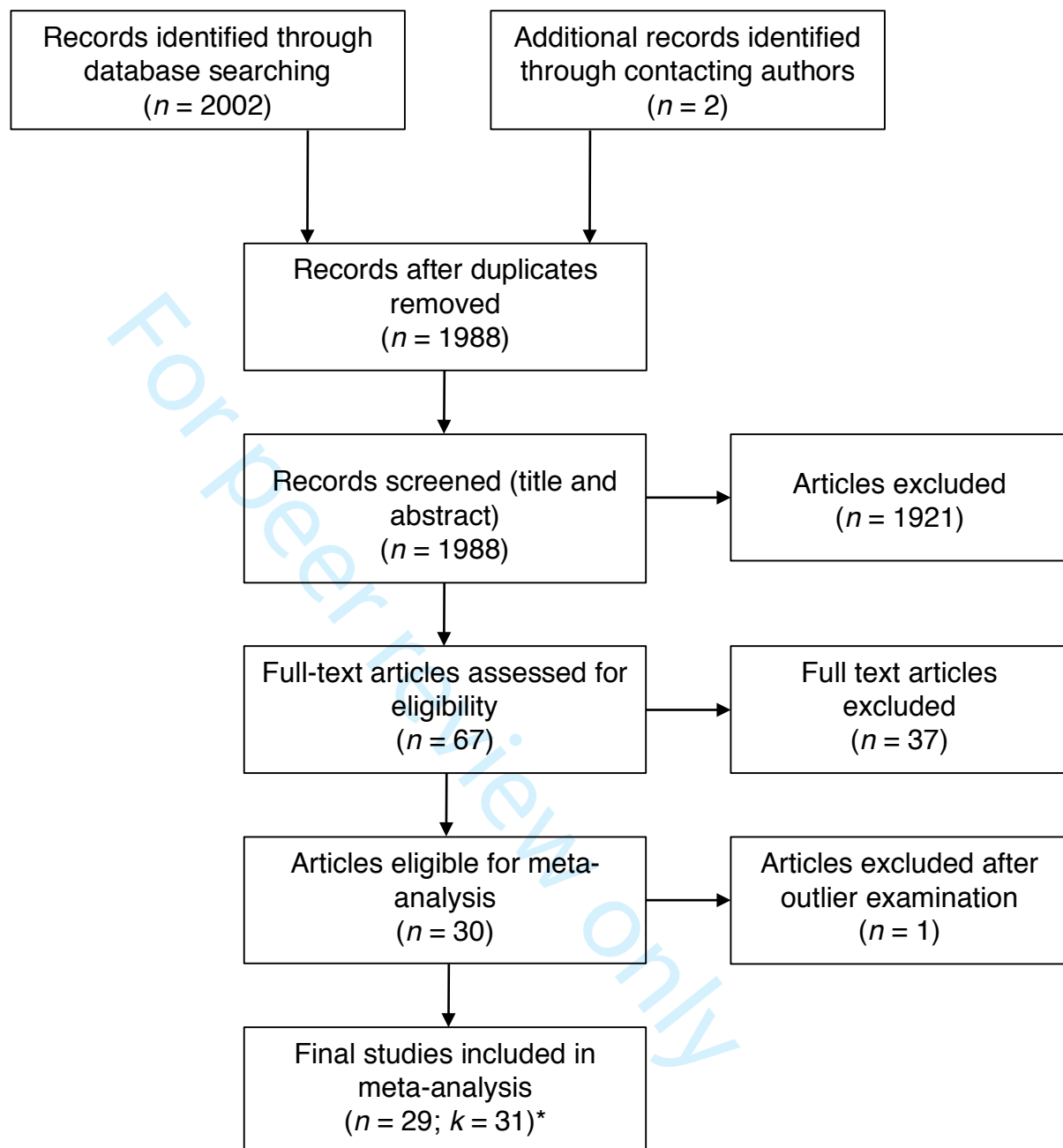
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LEGENDS TO FIGURES

Figure 1 Systematic literature search

Figure 2 Relationship between teamwork processes and performance

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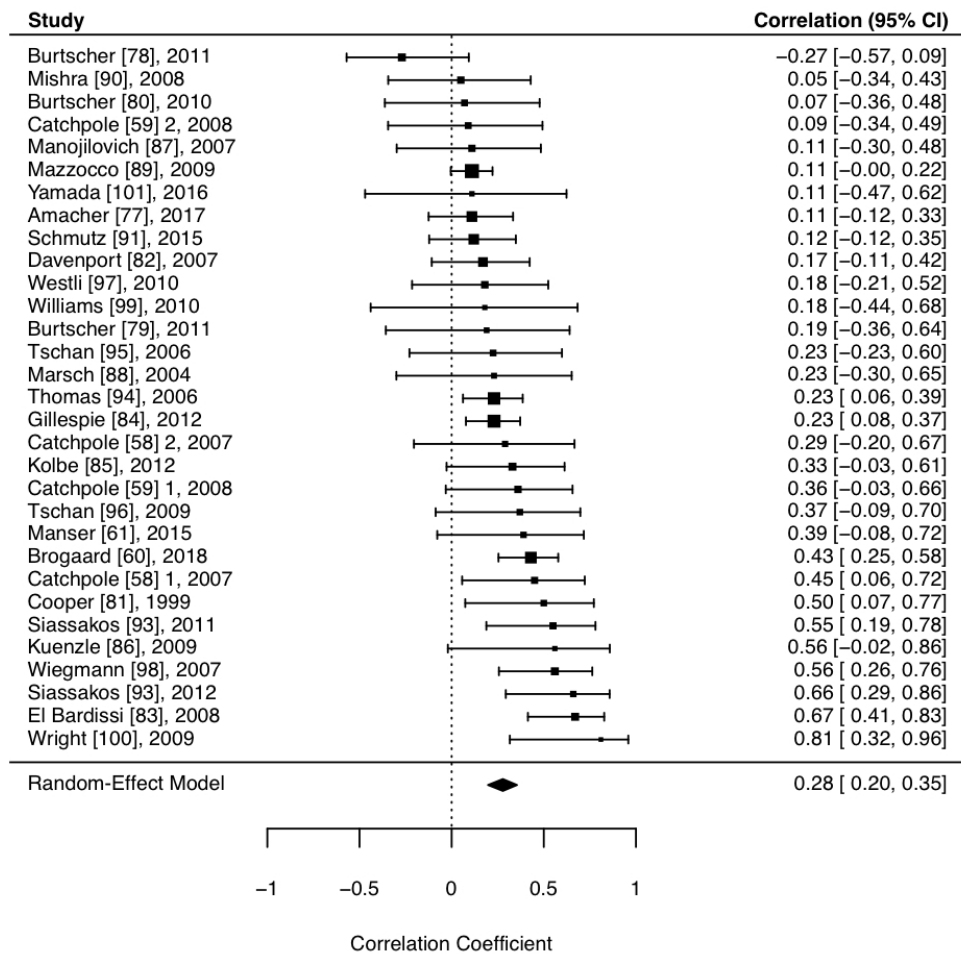


Figure 2. Relationship between teamwork processes and performance.

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
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Page 1 of 2

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

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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

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