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SYSTEMATIC REVIEW

Comprehensive geriatric assessment in older people: an umbrella review of health outcomes

Nicola Veronese[1], Carlo Custodero[2], Jacopo Demurtas[3], Lee Smith[4], Mario Barbagallo[1], Stefania Maggi[5], Alberto Cella[6], Nicola Vanacore[7], Pierangelo Lora Aprile[8], Luigi Ferrucci[9], Alberto Pilotto[2,6], The Special Interest Group in Systematic Reviews of the European Geriatric Medicine Society (EuGMS), The Special Interest Group in Meta-analyses and Comprehensive Geriatric Assessment of the European Geriatric Medicine Society (EuGMS)

[1]Geriatrics Section, Department of Internal Medicine, University of Palermo, Palermo, Italy
[2]Department of Interdisciplinary Medicine, University of Bari "Aldo Moro", Bari, Italy
[3]Clinical and Experimental Medicine PhD Program, Università di Modena e Reggio Emilia, Modena, Italy
[4]The Cambridge Centre for Sport and Exercise Sciences, Anglia Ruskin University, Cambridge, UK
[5]Institute of Neuroscience, Aging Branch, CNR, Padua, Italy
[6]Department Geriatric Care, Orthogeriatrics and Rehabilitation, E.O. Ospedali Galliera, Genova, Italy
[7]National Center for Disease Prevention and Health Promotion, Italian National Institute of Health, Rome, Italy
[8]Italian College of General Practitioners and Primary Care, Florence, Italy
[9]Intramural Research Program, National Institute on Aging, National Institute of Health, MD, USA

Address correspondence to: Nicola Veronese. Geriatric Unit, Department of Internal Medicine and Geriatrics, University of Palermo, via del Vespro, 141, 90127, Palermo, Italy. Tel/fax: 0039091 6554018. Email: nicola.veronese@unipa.it

Abstract

Background: Comprehensive geriatric assessment (CGA) has been in use for the last three decades. However, some doubts remain regarding its clinical use. Therefore, we aimed to capture the breadth of outcomes reported and assess the strength of evidence of the use of comprehensive geriatric assessment (CGA) for health outcomes in older persons.
Methods: Umbrella review of systematic reviews of the use of CGA in older adults searching in Pubmed, Embase, Scopus, Cochrane library and CINHAL until 05 November 2021. All possible health outcomes were eligible. Two independent reviewers extracted key data. The grading of evidence was carried out using the GRADE for intervention studies, whilst data regarding systematic reviews were reported as narrative findings.
Results: Among 1,683 papers, 31 systematic reviews (19 with meta-analysis) were considered, including 279,744 subjects. Overall, 13/53 outcomes were statistically significant ($P < 0.05$). There was high certainty of evidence that CGA reduces nursing home admission (risk ratio [RR] = 0.86; 95% confidence interval [CI]: 0.75–0.89), risk of falls (RR = 0.51; 95%CI: 0.29–0.89), and pressure sores (RR = 0.46; 95%CI: 0.24–0.89) in hospital medical setting; decreases the risk of delirium (OR = 0.71; 95%CI: 0.54–0.92) in hip fracture; decreases the risk of physical frailty in community-dwelling older adults (RR = 0.77; 95%CI: 0.64–0.93). Systematic reviews without meta-analysis indicate that CGA improves clinical outcomes in oncology, haematology, and in emergency department.
Conclusions: CGA seems to be beneficial in the hospital medical setting for multiple health outcomes, with a high certainty of evidence. The evidence of benefits is less strong for the use of CGA in other settings.

Keywords: comprehensive geriatric assessment, older people, umbrella review, systematic review

Key Points

- Comprehensive geriatric assessment is available to geriatricians and other medical and non-medical figures from three decades, but it is still poorly used.

- Our umbrella review including systematic reviews regarding comprehensive geriatric assessment in older people supported the use of this approach across several settings and clinical situations, even if supported by different degrees of evidence and strength.
- A solid literature supports the use of comprehensive geriatric assessment in hospital medical setting for multiple health outcomes, with a high certainty of evidence, whilst the evidence of benefits is less strong for the use of this approach in other settings.

Background

Comprehensive geriatric assessment (CGA) may be considered as a multidisciplinary diagnostic process aimed at identifying medical, psychosocial, and functional needs of older people that guide the development of a coordinated plan to manage the health complexity and to maximise overall health in older persons [1, 2]. Overall, CGA is usually initiated through a referral by the primary care physician or by clinicians working in the hospital setting. For this reason, CGA may be different according to the different settings of care and may impact on different outcomes [3].

CGA has been studied for approximately three decades [1]. Evidence from randomised controlled trials (RCTs) and meta-research has suggested that CGA significantly improves several outcomes in older patients across different conditions and settings [4]. For example, home CGA programs and CGA performed in the hospital have been shown to be consistently beneficial for several health outcomes [5], but results on the effectiveness of post-hospital discharge CGA programs, outpatient CGA consultation, and CGA-based inpatient geriatric consultation services are conflicting [5]. It has been widely recognised that the effectiveness of CGA programs may vary in different settings or specific clinical conditions suggesting CGA programs should be tailored to the specific purposes that they are for, such as preoperative assessment [6], admittance or discharged from emergency departments [7], orthogeriatric units [8] or evaluation of patients with specific medical conditions such as cancer. [9]

Since the body of research on this topic is rapidly expanding, we aimed to summarise the current knowledge of CGA using an umbrella review methodology to capture the breadth of outcomes reported and globally assess strength of evidence that CGA can improve multiple health outcomes in older persons.

Materials and methods

The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) recommendations guidelines were used to guide this umbrella review [10]. The full protocol is available in PROSPERO (CRD42021246239).

Data sources and searches

We searched Pubmed, Embase, Scopus, Cochrane library and CINHAL from database inception until 05 November 2021, with the search strategies reported in Supplementary Table 1 for systematic reviews with or without meta-analysis in older people using CGA versus standard/usual care or using CGA-based tools for predicting health outcomes of interest.

Study selection

For the aims of this work, we included: (i) systematic reviews with or without meta-analysis that evaluated observational studies with longitudinal (prospective or retrospective) design reporting on health outcomes in subjects receiving CGA, for a given condition, in older people; (ii) systematic reviews with or without meta-analysis that evaluated intervention studies, i.e. RCTs comparing CGA versus standard/usual care or no intervention, for a given condition, in older people. We excluded systematic reviews of cross-sectional studies, narrative reviews without a formal search of the literature, conference abstracts, meta-analyses that reported less than two studies for a single outcome, and letters to the editor. When more than one systematic review on the same research question was available that used similar study design (observational or RCTs), the one with the largest number of studies was selected.

Data extraction

Two reviewers (JD, CC) independently screened title/abstracts for eligibility, and when a consensus was not reached a third senior reviewer (NV) was consulted. The full texts of potentially eligible articles were retrieved, and two investigators (JD, CC) independently scrutinised each study for eligibility. When consensus was not reached, a third senior reviewer was consulted (NV).

The following information for each eligible work were extracted: first author name; publication year; number of included studies and number of participants: study population; type of effect size used; study design (RCT or observational); type of CGA by model/setting of delivery (e.g. geriatric ward, geriatric consultation team, acute geriatric care unit, emergency department interventions, pre- or perioperative CGA in non-orthopaedic surgical ward, geriatric trauma consultation, geriatric rehabilitation team, orthogeriatric care, multidimensional preventive home visit program); setting; number of participants with (cases) and without (controls) events in observational studies and people randomised to CGA or usual/standard care in RCTs. We also extracted the study-specific estimated relative risk for health outcomes (risk ratio, RR; odds ratio, OR; mean difference,

Table 1. GRADE assessment of significant associations of randomised controlled trials of comprehensive geriatric assessment

Certainty assessment							Summary of findings				
Participants (studies)	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Overall certainty of evidence	Study event rates (%)		Relative effect (95% CI)	Anticipated absolute effects	
							With usual/standard care	With comprehensive geriatric assessment		Risk with usual/standard care	Risk difference with comprehensive geriatric assessment
Surgery setting											
Mortality at 12 months in older adults in surgical ward (emergency surgery)											
4,458 (4 RCTs)	Not serious	Serious[a]	Not serious	Not serious	None	⨁⨁⨁◯ MODERATE	523/2,932 (17.8%)	206/1,526 (13.5%)	**RR 0.70** (0.54 to 0.90)	178 per 1,000	**54 fewer per 1,000** (from 82 fewer to 18 fewer)
Reduction in time to surgery in older adults in surgical ward (emergency surgery)											
1,107 (3 RCTs)	Not serious	Serious[a]	Not serious	Not serious	Publication bias strongly suspected[b]	⨁⨁◯◯ LOW	252/536 (47.0%)	390/571 (68.3%)	**RR 0.60** (0.50 to 0.73)	470 per 1,000	**188 fewer per 1,000** (from 235 fewer to 127 fewer)
Delirium in older adults hospitalised under nonorthopedic surgical teams for operative or nonoperative management											
1,139 (5 RCTs)	Serious[c]	Not serious	Not serious	Not serious	None	⨁⨁⨁◯ MODERATE	90/536 (16.8%)	49/603 (8.1%)	**RR 0.52** (0.37 to 0.92)	168 per 1,000	**81 fewer per 1,000** (from 106 fewer to 13 fewer)
Length of stay (days) in older adults hospitalised under nonorthopedic surgical teams for operative or nonoperative management											
617 (3 RCTs)	Serious[c]	Not serious	Not serious	Not serious	None	⨁⨁⨁◯ MODERATE	264	353	-	-	MD **1.98 days lower** (3.09 lower to 0.88 lower)
Orthopaedics											
Mobility in older adults with hip fracture trauma											
982 (6 RCTs)	Not serious	Serious[a]	Not serious	Not serious	None	⨁⨁⨁◯ MODERATE	495	487	-	-	SMD **0.32 SD higher** (0.12 higher to 0.52 higher)
Delirium in older adults with hip fracture trauma											
1,443 (6 RCTs)	Not serious	Not serious	Not serious	Not serious	None	⨁⨁⨁⨁ HIGH	313/667 (46.9%)	283/776 (36.5%)	**OR 0.71** (0.54 to 0.92)	469 per 1,000	**84 fewer per 1,000** (from 146 fewer to 21 fewer)
ADL in older adults with hip fracture trauma											
1,291 (5 RCTs)	Very serious[d]	Serious[a]	Not serious	Not serious	None	⨁◯◯◯ VERY LOW	648	643	-	-	SMD **0.26 SD higher** (0.04 higher to 0.49 higher)
Mortality in older adults with hip fracture trauma											
2088 (8 RCTs)	Very serious[d]	Not serious	Not serious	Not serious	None	⨁⨁◯◯ LOW	125/1,047 (11.9%)	91/1,041 (8.7%)	**OR 0.73** (0.54 to 0.98)	119 per 1,000	**29 fewer per 1,000** (from 51 fewer to 2 fewer)
Hospital											
Institutionalisation in older adults admitted to hospital at discharge											
4,459 (12 RCTs)	Not serious	Not serious	Not serious	Not serious	None	⨁⨁⨁⨁ HIGH	674/2,300 (29.3%)	579/2,159 (26.8%)	**RR 0.86** (0.75 to 0.99)	293 per 1,000	**41 fewer per 1,000** (from 73 fewer to 3 fewer)
Discharge at home in older adults admitted to hospital											
6,799 (16 RCTs)	Not serious	Serious[a]	Not serious	Not serious	None	⨁⨁⨁◯ MODERATE	1,852/3,301 (56.1%)	2,079/3,498 (59.4%)	**RR 1.060** (1.009 to 1.100)	561 per 1,000	**34 more per 1,000** (from 5 more to 56 more)
Falls in older adults admitted to hospital for acute medical condition or injury											
658 (3 RCTs)	Not serious	Not serious	Not serious	Not serious	None	⨁⨁⨁⨁ HIGH	40/469 (8.5%)	14/189 (7.4%)	**RR 0.51** (0.29–0.89)	85 per 1,000	**41 fewer per 1,000** (from 61 fewer to 9 fewer)
Pressure sores in older adults admitted to hospital for acute medical condition or injury											
658 (3 RCTs)	Not serious	Not serious	Not serious	Not serious	None	⨁⨁⨁⨁ HIGH	36/469 (7.7%)	16/189 (8.5%)	**RR 0.46** (0.24–0.89)	77 per 1,000	**41 fewer per 1,000** (from 58 fewer to 8 fewer)
Institutionalisation in older adults admitted to hospital at 3 and 6 months											
6,285 (14 RCTs)	Not serious	Not serious	Not serious	Not serious	None	⨁⨁⨁⨁ HIGH	568/3,061 (18.6%)	481/3,224 (14.9%)	**RR 0.80** (0.71–0.89)	186 per 1,000	**37 fewer per 1,000** (from 54 fewer to 20 fewer)
Non-hospital setting											
Physical frailty in community-dwelling older adults											
786 (3 RCTs)	Not serious	Not serious	Not serious	Not serious	None	⨁⨁⨁⨁ HIGH	133/351 (37.9%)	135/435 (31.0%)	**RR 0.77** (0.64 to 0.93)	379 per 1,000	**87 fewer per 1,000** (from 136 fewer to 27 fewer)

CI, confidence interval; **RR,** risk ratio; **MD,** mean difference; **SMD,** standardised mean difference; **OR,** odds ratio. [a]I^2 between 50% and 75%. [b]Egger's test (P-value) < 0.05. [c]Between 10% and 30% of RCTs with a high RoB. [d]Risk of bias present in more than 30% of the RCTs.

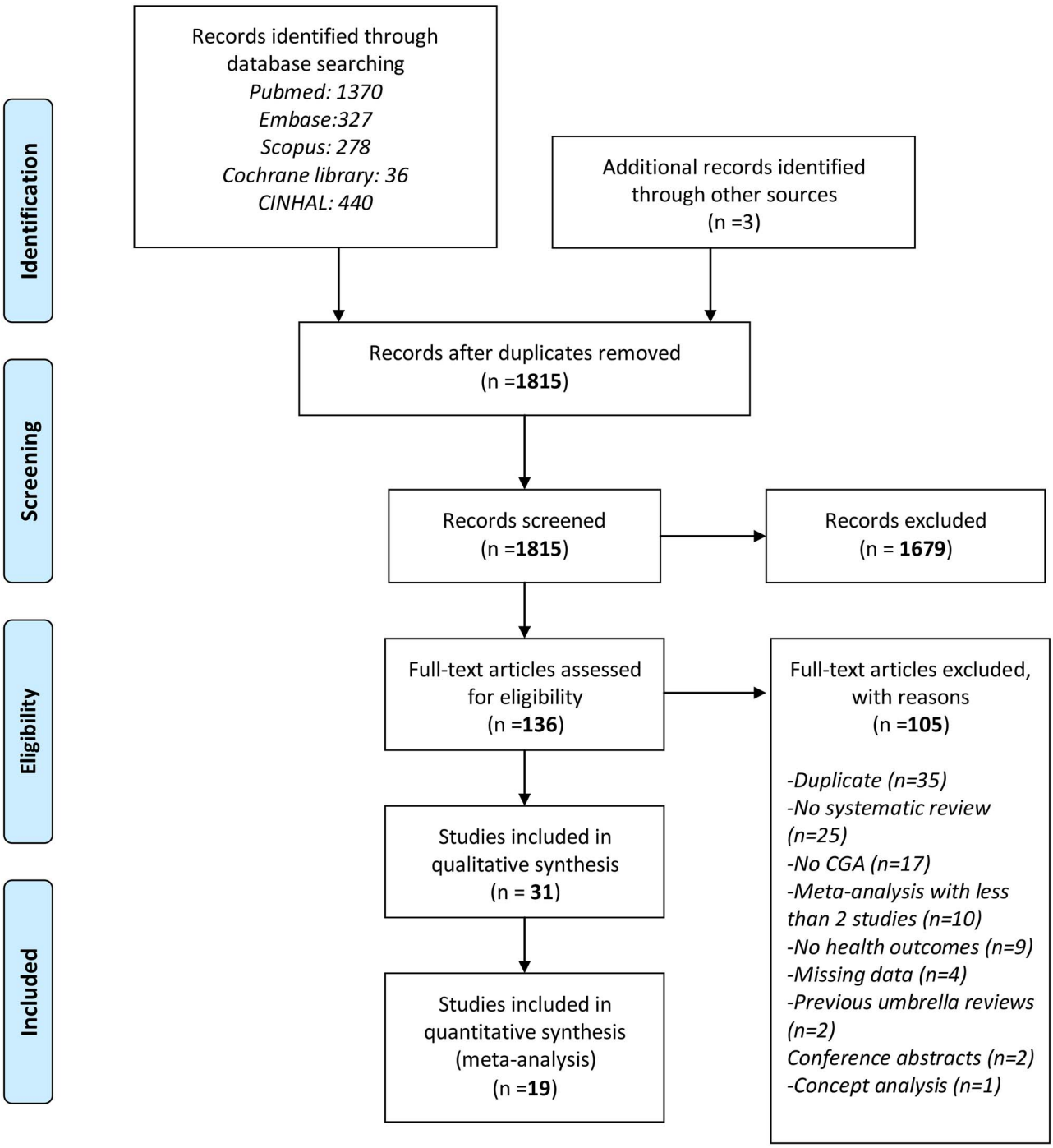

Figure 1. PRISMA flow-chart.

MD; standardised mean difference, SMD) and 95% confidence intervals (CIs). We finally extracted the data for the Assessment of Multiple Systematic Reviews (AMSTAR)-2 tool. [11]

Quality assessment

Two reviewers (CC, JD) assessed the methodological quality of the included meta-analyses using AMSTAR-2 [11, 12] that ranks the quality of a systematic review from critically low to high according to sixteen predefined grades.

Data synthesis and analysis

For each meta-analysis, we estimated the summary effect size and its 95% confidence interval (CI) by using the random-effects DerSimonian and Laird (DL). [13] We also estimated the prediction interval (PIs) and its 95% CI, which further accounts for between-study effects and estimates the certainty of the association if a new study addresses that same association [14, 15]. Between-study inconsistency was estimated with the I^2 metric, with values between 50% and 75% indicative of high heterogeneity and ≥75% indicating very large heterogeneity [16]. We calculated the evidence of

Table 2. Summary of Findings of the Systematic Reviews (Without Meta-analysis) included of the randomised controlled trials

Author, year	Sample size	Surgery	Orthopaedics	Hospital	Non-hospital
Boult (2009)	5,925	Not available	Not available	Not available	Increase of quality of care in 4/4 RCTs included, quality of life, use of health care
Daniels (2020)	1,143	Reduction of length of stay in 2/4 RCTs	Not available	Not available	Not available
Garrad (2019)	1,643	Not available	Not available	Not available	No effect of CGA on mortality and hospital/ED admission
Marino (2018)	3,382	Not available	Not available	Not available	Reduction of ED/hospital admission in $^{3}/_{4}$ studies included
McCusker (2006)	6,606	Not available	Not available	Little effect on ED utilisation for hospital-based interventions (excluding ED-based interventions)	Reduction of ED/hospital admission in outpatient and/or primary care or home care settings
Neyens (2011)	3,759	Not available	Not available	Not available	Reduction of falls in 4/8 RCTs in nursing home residents

RCT: randomised controlled trial; CGA: comprehensive geriatric assessment; ED: emergency department.

small-study effects (i.e. whether small studies inflated effect sizes). We used the regression asymmetry test [17], using a *P*-value <0.10 with more conservative effects in larger studies as indicative of small-study effects [18]. Furthermore, we assessed if the largest study in each meta-analysis in terms of participants was statistically significant, using a *P*-value <0.05.

Finally, we applied the excess of significance test [19]. The larger the difference between observed (O) and expected (E) number of studies, the higher the degree of excess significance. Because of the limited statistical power of this test, a lenient significance threshold ($P < 0.10$) was adopted [20].

All analyses were conducted with STATA 13.0 (Stata Corp LP, College station, TX, USA).

Grading the evidence

When the *P*-value for the random effect was <0.05, we evaluated the evidence derived from RCTs using the GRADE (Grading of Recommendations, Assessment, Development and Evaluation) assessment [21]. We also considered 95% PI (excluding the null or not), the presence of large heterogeneity ($I^2 > 50\%$), small study effects ($P < 0.10$), and excess significance ($P < 0.10$) as possible indicators of other biases in the available evidence. Findings of the systematic reviews without meta-analysis were reported descriptively.

Results

Literature review

As shown in Figure , we identified 1,815 unique manuscripts across all searched databases. After excluding 1,679 abstracts, 136 full texts were examined and a total of 31 systematic reviews were considered eligible, 19 including a meta-analysis. References of the included works are reported in Supplementary Table 2.

Findings from the randomised controlled trials

As reported in Supplementary Table 3, the 53 outcomes included a median of six RCTs (range: 3–21) with a median of 2,088 older participants (range: 355–14,597) for a total of 182,214 older people. Altogether, about half of the outcomes were studied in hospital setting (26/53), 10/53 in orthopaedics, nine in surgery setting, five among community-dwellers, three in outpatients. Regarding the type of CGA used, the majority (18/53) used CGA-ward. Among the outcomes investigated, mortality was the most common explored (14/53), followed by disability (8/53), and by hospitalisation/re-hospitalisation (4/53) (Supplementary Table 3).

Overall, 13/53 (=25%) of the outcomes included reported that CGA is statistically significantly superior to usual/standard care in RCTs. Table 1 shows the GRADE assessment of RCTs of CGA, divided by setting. In emergency surgery setting, the use of CGA was associated with lower mortality risk at 12 months (RR = 0.70; 95%CI: 0.54–0.90; moderate strength) and a lower time to surgery (RR = 0.60; 95%CI: 0.50–0.73; low strength). In older adults admitted to a surgical service (excluding orthopaedic ward), there was moderate strength of evidence that perioperative CGA can significantly reduce delirium compared to usual/standard care (RR = 0.52; 95%CI: 0.37–0.92) and length of stay in hospital of approximately 2 days (MD = −1.98; 95%CI: −3.09 to −0.88). In older patients with hip fracture following a trauma, CGA significantly reduced the risk of delirium (OR = 0.71; 95%CI: 0.54–0.92; high strength), prevented mobility decline (SMD = 0.32; 95%CI: 0.12–0.52; moderate strength), reduced mortality (OR = 0.73; 95%CI: 0.54–0.98; low strength) and disability in activities of daily living [ADL] (SMD = 0.26; 95%CI: 0.04–0.49; very low strength) compared to usual/standard care. In older adults admitted to hospital for acute medical condition or injury, with a high certainty of evidence, CGA significantly reduced nursing

Table 3. Summary of Findings of the Systematic Reviews (Without Meta-analysis) included of the observational studies

Author (year)	Sample size	Surgery	Orthopaedics	Hospital	Non-hospital
Caillet (2014)	12,900	Optimal prediction of mortality with CGA-based tools and domains	Not available	Not available	Not available
De Almeida (2015)	58,244	Not available	Not available	Not available	CGA captures needs of older patients
Graf (2011)	2,476	Not available	Not available	Good discrimination of adverse outcomes in ED	Not available
Lin (2016)	815	Optimal prediction of mortality with CGA-based tools	Not available	Not available	Not available
Scheepers (2020)	212	Not available	Not available	CGA may help identify higher risk of non-completion of chemotherapy for frail people	Not available
Terret (2015)	425	Not available	Not available	CGA may help identify higher risk of death for frail people and fit patients for curative therapy	Not available

CGA: comprehensive geriatric assessment; ED: emergency department.

home admission at discharge (RR = 0.86; 95%CI: 0.75–0.89), the risk of falls (RR = 0.51; 95%CI: 0.29–0.89) and pressure sores (RR = 0.46; 95%CI: 0.24–0.89) (Table 1). Moreover, CGA increased the probability to be discharged at home after a hospitalisation (RR = 1.06; 95%CI: 1.009–1.10) even if supported by a moderate strength of evidence according to the GRADE. Finally, in community-dwelling older adults, CGA reduced the risk of physical frailty (RR = 0.77; 95%CI: 0.64–0.93; high strength).

Supplementary Table 3 reports the ancillary analyses for the 53 outcomes of the RCTs included in our analyses. Heterogeneity was low in 24/53 ($I^2 < 50\%$), high in 18/53 (I^2 between 50 and 75%) and very high in 11/53 outcomes. Small study effect, as p-value of the Egger's test <0.10, was present in 13/53 of the outcomes included, whereas the excess significance bias was present in 10/53 outcomes. The largest study reported statistically significant results in 14/53 outcomes. The prediction intervals included the null values in all the outcomes evaluated.

Supplementary Table 4 reports the quality assessment made according to the AMSTAR2. Overall, among the 19 meta-analyses included, two were rated as of high quality, four of medium, seven low quality and the others very low. Among the 12 systematic reviews included only one was rated high, two systematic reviews scored low, whereas the others were deemed to be critically low, as shown in Supplementary Table 4.

Findings from the narrative systematic reviews

Overall, 12 systematic reviews without a formal meta-analysis for a total of 97,530 participants were included (Table 2 for intervention studies, Table 3 for observational studies; other information in Supplementary Table 5). In systematic reviews of RCTs, CGA seems to lead to an improvement in quality of care in older outpatients affected by chronic conditions, whilst the effect on hospital/emergency department admission, use and costs of health services was less clear. In 3,759 nursing home residents, CGA decreased the risk of falls in 4/8 RCTs included. When considering CGA-based tools, the CGA may help the clinician to better tailor therapy and reduce mortality in 425 patients affected by non-Hodgkin lymphoma. Similarly, CGA-based tools reduced the risk of mortality in older patients undergoing surgery and with solid tumour cancer.

Discussion

In this umbrella review, including 31 systematic reviews and approximately 300,000 older participants, we found data on the effectiveness of CGA across different settings and conditions and towards multiple outcomes. Focusing on intervention studies we studied of the effect of CGA on 53 different outcomes including information on 'hard outcomes' such as mortality, risk of hospitalisation and admission to nursing home. Systematic reviews without meta-analysis completed this picture also giving information regarding the use of CGA-based tools, particularly in patients affected by cancer.

In the meta-analyses of the RCTs, we found high certainty of the evidence regarding the importance of CGA in reducing nursing home admission, risk of falls and pressure sores in hospital setting. These findings indicate that all older patients admitted to hospital should be evaluated through the CGA not only for decreasing the institutionalisation, but also for decreasing other outcomes, such as falls and pressure sores, that can further increase the length of stay in hospital. These findings are of clinical importance since CGA reduced the risk of nursing home admission, falls, and pressure sores of about 41 units for every 1,000 older patients evaluated, when compared to usual/standard care, indicating that in

hospital setting CGA is a highly beneficial intervention for older patients.

Moreover, our works indicated that in older patients affected by hip fracture, CGA significantly prevented delirium. Delirium is amog the most frequent complication in people undergoing surgery for a hip fracture, being associated with higher rates of disability and cognitive recovery, and a prolonged hospital stay with consequent higher mortality rates and treatment costs [22]. Moreover, there is an increasing evidence that episodes of delirium may increase the risk of dementia after hospital discharge [23, 24]. Therefore, to reduce the rate of delirium in older patients affected by a hip fracture is a priority also from a public health perspective [25] and in this sense CGA seems to be highly effective when compared to usual/standard care as the evidence supporting this finding is not affected by any bias. Furthermore, 84 fewer patients out of 1,000 patients affected by hip fracture and treated with CGA experienced delirium. Moreover, even if supported by a lower certainty of evidence, CGA seems to be beneficial in improving mobility, disability and mortality in patients with a hip fracture further supporting the benefits of an integrated care of geriatrics and orthopaedics, i.e. orthogeriatric model [26].

In the surgery setting, CGA was useful in decreasing the risk of mortality at 12 months and time to surgery in emergency, even if this evidence is supported by a high heterogeneity of the findings. Moreover, the finding that CGA can decrease the length of stay in general surgery by approximately 2 days is of interest, but again the poor quality of the RCTs included in this investigation did not permit to have firm conclusions regarding this outcome.

Finally, meta-analyses of the RCTs, suggested that CGA is able to significantly reduce physical frailty in community-dwelling older adults with a high certainty of evidence, further suggesting that CGA could be beneficial not only in the hospital setting, but also in primary care settings [27]. However, among the 53 outcomes included, only five included community-dwellers thus further research is needed in this setting taking hard outcomes such as mortality, nursing home admission and hospitalisation as endpoints.

Narrative systematic reviews completed the picture of CGA giving some information regarding CGA-based tools in populations different from those treated in RCTs, such as outpatients having cancer. A strong limitation of this evidence is that the quality assessment of this kind of works is not possible and, therefore, we cannot distinguish high quality evidence from lower grades. Altogether these findings suggest that CGA can be used for evaluating older patients having solid tumour or haematological cancers and undergoing treatments typical of these conditions, such as chemotherapy or radiotherapy and finally indicating the role of CGA in personalised medicine in older patients [9].

Our review is unique since it is the first comprehensive literature review of the evidence on use of CGA in different settings (i.e. hospital, outpatients, community) and its effectiveness for prevention of several relevant clinical outcomes. On the contrary, a previous umbrella review on the same topic summarised CGA intervention definitions and benefits, only from systematic reviews and meta-analysis including interventional studies carried out in hospital setting [5]. Another review of reviews was more broadly focused on different elements of the integrated care approach for older people and among others also CGA, but did not analyse effect on clinical outcomes [28]. Both these works, even if important, only provided a narrative synthesis of the evidence and thus not performing any evaluation of their strength.

We believe that our umbrella review can add some novel findings to the discussion regarding the importance of CGA in daily clinical practice. In particular, we think that to judge several outcomes at high certainty of evidence can encourage the use of CGA in these specific areas and settings (such as hospital or orthogeriatrics). At the same time, our umbrella review indicates some promising areas of research, e.g. oncology, in which the use of CGA could be strenghtened. Finally, some important topics in geriatric medicine are still not covered by scientific literature regarding CGA, i.e. palliative care. Despite the fact that CGA has been used from three decades and, as reported in our umbrella review, a large literature exists regarding its positive effects, this intervention is still under-used worldwide, probably suggesting that some obstacles are still present. A number of barriers to the implementation of CGA includes the lack of guidelines, professional and patients' factors, need for professional interactions, capacity for organisational change as well as social, political and legal factors and economic aspects [29]. In this regard, for overcoming these barriers, a better approach to research, clinical activity and teaching might be performed and encouraged by geriatricians, also in concerted actions of other health professionel interested in CGA [30].

The findings of our umbrella review must be considered within its limitations. First, the RCTs included in the systematic reviews with meta-analyses of CGA intervention are probably underpowered since small study effect and excess significance bias was present in about ¼ of outcomes included. Moreover, different definitions of CGA may influence our results in terms of clinical heterogeneity: we tried to overcome this limitation using a stringent value of $I^2 < 50\%$ for detecting this issue and for giving high certainty of evidence according to the GRADE. Similarly, the prediction intervals included the null value in all outcomes investigated, suggesting that further research is needed. Second, it is known that meta-analyses have important limitations [31] and their results may also depend on choices made about what estimates to select from each individual study and how to report them in the meta-analysis (e.g. in our umbrella review several meta-analyses did not report information regarding the type of CGA used) [31]. Furthermore, applying the criteria suggested by the AMSTAR-2, we observed that several systematic reviews had low/critically low rating, mainly owing to not reporting of funding and not pre-registering protocols. Moreover, most studies on CGA

focused on mortality, but the need for more studies investigating patient-centered outcomes is urgent. Perhaps among limitations or opportunities for future research. Finally, even if the GRADE is the preferred method for assessing the certainty of evidence, this assessment does not mean automatically the definition of a recommendation, such as a in guideline.

Conclusions

In this umbrella review including 19 independent meta-analyses and 53 outcomes, we found that CGA could be beneficial in the hospital setting with a high certainty of the evidence and with a less strong certainty in surgery, orthopaedics and primary care settings. In older patients affected by cancer the use of CGA-based tools seems to be promising, but further intervention research is urgently needed. Overall, our findings support the use of CGA in clinical practice, also encouraging new research in different directions in which the geriatrician could be useful for tailored and personalised medicine.

Supplementary Data: Supplementary data mentioned in the text are available to subscribers in *Age and Ageing* online.

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