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Review Article

Computerized Decision Support Systems for Nursing Homes: A Scoping Review

Abir Abdellatif MSc [a,b,c], Jacques Bouaud PhD [a,d], Carmelo Lafuente-Lafuente MD, PhD [b,e], Joël Belmin MD, PhD [a,b,e,*], Brigitte Séroussi MD, PhD [a,f]

[a] Sorbonne Université, Inserm, Université Sorbonne Paris Nord, LIMICS, UMR S_1142, Paris, France
[b] APHP, Hôpital Charles-Foix, Ivry-sur-Seine, France
[c] Teranga Software, Paris, France
[d] AP-HP, Direction de la Recherche Clinique et de l'Innovation, Paris, France
[e] Faculté de Médecine, Sorbonne Université, Paris, France
[f] APHP, Hôpital Tenon, Paris, France

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A B S T R A C T

Objectives: To summarize the research literature describing the outcomes of computerized decision support systems (CDSSs) implemented in nursing homes (NHs).
Design: Scoping review.
Methods: Search of relevant articles published in the English language between January 1, 2000, and February 29, 2020, in the Medline database. The quality of the selected studies was assessed according to PRISMA guidelines and the Mixed Method Appraisal Tool.
Results: From 1828 articles retrieved, 24 studies were selected for review, among which only 6 were randomized controlled trials. Although clinical outcomes are seldom studied, some studies show that CDSSs have the potential to decrease pressure ulcer incidence and malnutrition prevalence. Improvement of process outcomes such as increased compliance with practice guidelines, better documentation of nursing assessment, improved teamwork and communication, and cost saving, also are reported.
Conclusions and implications: Overall, the use of CDSSs in NHs may be effective to improve patient clinical outcomes and health care delivery; however, most of the retrieved studies were observational studies, which significantly weakens the evidence. High-quality studies are needed to investigate CDSS effects and limitations in NHs.

With aging, people are suffering from multiple chronic diseases, leading to a high prevalence of dependency, and a high number of older adults living in nursing homes (NHs) despite the improvement of care at home.[1,2] Because they are suffering from multiple chronic diseases, older adults are subject to polypharmacy, which puts them at risk of taking potentially inappropriate drugs and experiencing adverse drug events (ADEs). Thus, NH residents are a highly vulnerable population with severe medical issues that require complex management with a high level of geriatric and nursing expertise.[3] However, nurses' expertise is often lacking due to insufficient knowledge and limited staff training efforts because of high staff turnover. Missed nursing care is common in NHs due to inadequate time or resources.[4] Besides, health professionals are involved in high regulatory requirement that may conflict with or distract from clinical practice guideline implementation.[5] Thus, studies have reported that NH residents may experience several potentially preventable clinical complications, such as pressure ulcers, falls, malnutrition, or ADEs.[6–8] Defined as information systems where characteristics of individual patients are matched to a computerized knowledge base to generate patient-specific recommendations,[9] computerized decision support systems (CDSSs) have proven to be efficient in detecting medical errors and improving care quality in both hospital settings and primary

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* Address correspondence to Joël Belmin, MD, PhD, Hôpital Charles-Foix and Sorbonne Université, 7 avenue de la République, 94200 Ivry sur-Seine, France.
E-mail address: j.belmin@aphp.fr (J. Belmin).

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care centers.[10,11] However, it is not clear whether CDSSs have the same efficiency in NHs and little is known about their impact on nursing practices and NH resident clinical outcomes.[12]

In the perspective of enriching the NetSoins electronic health record (EHR) system, currently implemented in nearly half of the French NHs nationwide, with the development of a CDSS module to support the prevention and management of malnutrition, pressure ulcers, osteoporotic fractures, and drug prescription errors, we conducted a scoping review to identify published CDSSs implemented in NHs and assess the factors that contributed to their effectiveness regarding NH resident clinical outcomes and care delivery. Another objective was to study NH health care professional satisfaction when using a CDSS and their level of adoption of CDSSs in routine practice. Beyond preliminary results previously reported,[13] the objective of this article was to present the complete methods, results, and discussion of the scoping review.

Methods

Search Strategy

We searched PubMed/MEDLINE for articles written in the English language and published between January 2000 and February 2020. Search terms were selected to cover the 2 dimensions of interest: decision support systems and nursing homes. The query used MeSH terms, for example, "decision support systems, clinical", "reminder systems", "expert systems", "geriatric nursing", "homes for the aged", "nursing homes", "residential facilities", and key words, for example, clinical decision support tool, computer-based decision support, long-term care homes, care home. Two of the authors (AA and CL) independently screened the titles and abstracts of the retrieved articles to assess their relevance based on eligibility criteria. Backward citation tracking also was performed to identify additional relevant articles. Full-text articles were reviewed for articles that both reviewers finally considered relevant.

Study Eligibility Criteria

The following inclusion criteria were used for the selection of relevant studies: (1) the study had to evaluate the implementation of a CDSS in NHs, (2) the CDSS used should have to provide patient-specific recommendations to be considered by a health care practitioner (eg, physicians, pharmacists, nurses), (3) the CDSS impact defined in terms of resident clinical outcomes or NH care delivery had to be assessed. Studies were excluded when (1) the described CDSS was used in hospitals or primary health care settings but not in NHs, (2) the study described the use of a noncomputerized CDSS, (3) there was no assessment of the CDSS implementation.

Study Appraisal and Synthesis Methods

We assessed the quality of selected studies using the Mixed Method Appraisal Tool (MMAT),[14] version 2018, a qualitative scale that yields a 5-value score (0%, 25%, 50%, 75%, or 100%). The tool evaluates the aim of a study, its adequacy to the research question, the methodology used, the study design, participant recruitment, data collection, data analysis, presentation of findings, and the discussion and conclusion sections of the article. Studies were considered to be of "low quality," "medium quality," and "high quality" when the MMAT score was, respectively, 0 or 25%, 50% or 75%, and 100%.

Selected articles were first manually characterized using the following criteria: design of the study, type of the study, MMAT score, CDSS recipients (number of residents, number of facilities, patient characteristics), CDSS target users (nurses, pharmacists, physicians), CDSS features, and CDSS outcomes (including clinical outcomes and process outcomes). Interrater disagreements were solved by consensus.

Because we did not retrieve enough studies reporting the same outcome in a similar way and because studies were not sufficiently homogeneous regarding the patients and the CDSSs studied, we did not pool data in a random-effects meta-analysis. However, we narratively described the findings of included studies, organizing them according to the special issue addressed by the CDSS and presenting their results on (1) clinical outcomes, (2) care delivery, and (3) other criteria including users' satisfaction and adoption.

Results

Article Selection

The search query returned 1809 references. Analysis of titles and abstracts discarded 1747 references that were not relevant to the research question. A manual analysis of the citations of the remaining 62 articles was performed and identified an additional set of 19 references. We finally reviewed 81 full-text articles among which we excluded 57 articles that did not satisfy eligibility criteria, for example, 5 studies[15−19] were removed because information was missing to assess CDSSs. Finally, 24 articles were included for the final analysis. The corresponding PRISMA flow diagram is depicted in Figure 1.

General Overview

Included studies (n = 24) describe 20 different unique CDSSs implemented to support NH resident care quality. We have classified the articles according to the issue addressed by the CDSS as follows: malnutrition and pressure ulcer prevention and management (n = 7),[12,20−25] drug prescription (n = 8),[26−33] medication review (n = 6),[34−39] and disease management (n = 3).[40−42] Studies were primarily conducted in the United States (n = 12),[20−22,29−34,40−42] in European countries (n = 9),[12,23−25,35−39] namely Sweden (n = 4),[35−38] Norway (n = 3),[12,23,24] Belgium (n = 1),[25] and the Netherlands (n = 1).[39] Three studies were conducted in Canada.[26−28] Studies follow different designs, with 6 cluster randomized controlled trials (RCTs),[25,26,29−31,34] 4 non-RCTs,[12,21,24,37] 13 observational studies,[20,22,23,27,28,32,35,36,38−42] and 1 ancillary study.[33] According to the MMAT score, most of the studies are of high[20−23,26,30,36,37,42] or medium quality (ie, MMAT score of 75%[12,24,25,27,31,32,35,38] or 50%[28,29,39−41]). Only 2 studies[33,41] were scored of low quality, both with an MMAT score of 25%. None was excluded from the analysis based on the MMAT score. Full details of quality and bias risk assessment are provided for each study in the supplementary material (Supplementary Tables 1 and 2).

Description of the Studied CDSSs

In all cases, CDSSs are computerized, knowledge-based systems providing decision support generated from clinical practice guidelines or experts' recommendations. Fourteen CDSSs are developed as software either embedded within EHRs (n = 8),[20−23,34,37,40,41] or connected to computerized provider order entry (CPOE) systems (n = 6),[26,29−31,33,42] leading to decision support automatically triggered from data input in EHR or CPOE systems. The remaining 6 CDSSs[25,27,28,32,35,39] are standalone systems requiring users to re-enter patient data in separate software.

CDSSs applied to malnutrition and pressure ulcer prevention and management aim at supporting nurses in the implementation of clinical practice guidelines (eg, repositioning standards of care). Three of 7 CDSSs[12,23,24] display alerts automatically triggered from risk assessment instruments (eg, the Risk Assessment Pressure Scale for pressure ulcer risk screening, or the Mini Nutritional Assessment scale

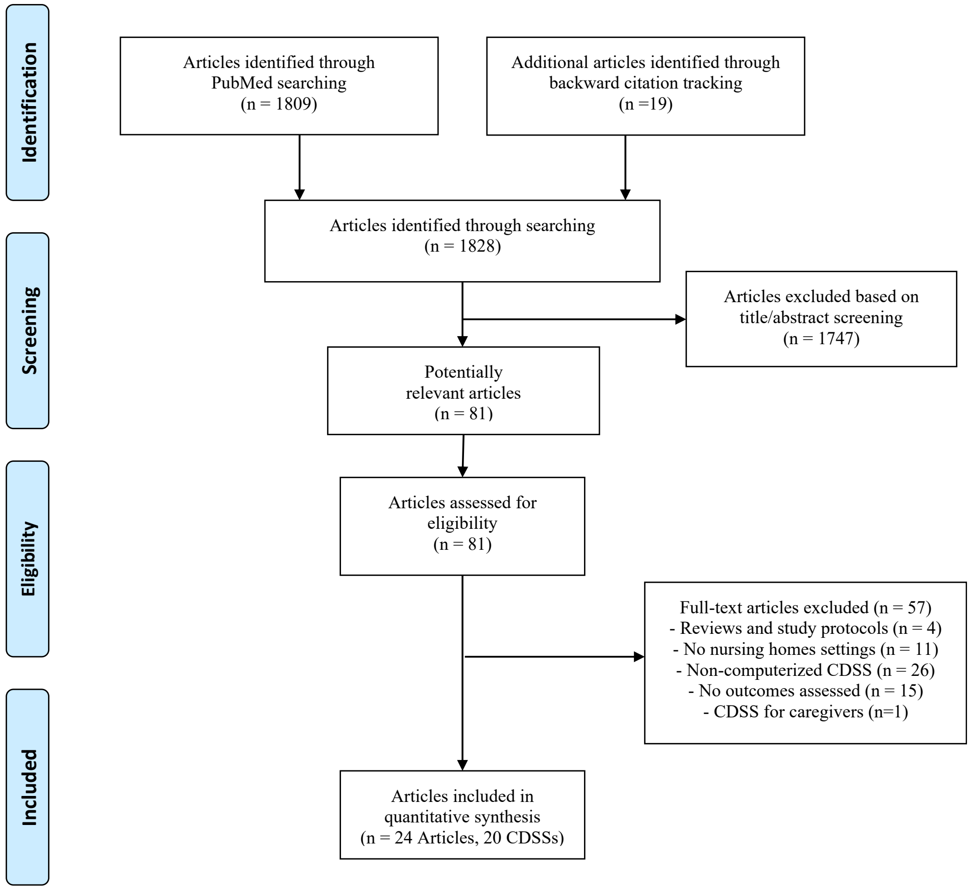

Fig. 1. PRISMA flow diagram.

to assess the nutritional status). Risk assessment is continuously updated from new input data, which triggers alerts when the computed risk exceeds a certain threshold. More recently, based on connected devices, Yap et al.[22] developed a CDSS operating from data on the frequency and position of residents, wirelessly transferred from sensors to estimate nurse practices before and after visual monitors were activated.

CDSSs applied to drug prescription and medication review are usually implemented as CPOE systems identified as a means to improve medication safety.[43] They usually display warning messages to alert physicians on noncompliant drug prescription. Subramanian et al.[33] proposed a system for NH residents with renal insufficiency able to display 4 categories of alerts to show the recommended doses, the recommended frequencies, the drugs to be avoided, and when additional information was needed to compute creatinine clearance. Colón-Emeric et al.[42] developed an alert-based CPOE system based on clinical practice guidelines to manage geriatric problems in NHs (eg, falls, fever, pneumonia, urinary tract infection, and osteoporosis). Alexander[40] developed a CDSS to alert clinicians about changes in resident condition either based on episodic events (eg, a dehydration alert is sent to a provider if an episode of bowel incontinence is reported within a 24-hour period) or successive clinical assessments (eg, a decline in condition alert is sent when the resident ability to make decisions declines over 2 successive systematic evaluations).

CDSS alerts are usually displayed at the moment of the prescription,[26,29–32] but they could also be sent as e-mails, or used in phone calls between pharmacists and physicians. For instance, de Wit et al[39] developed a standalone pharmacy CDSS for medication review that automatically triggers alerts to the pharmacist who then had to contact the prescriber physician to indicate how to revise the misprescription. Johansson-Pajala et al[36–38] proposed a CDSS as a Web application connected to the NH EHR system. When using the CDSS, registered nurses could assess patient symptoms and initiate the medication review to be sent to the physician who then could make the final decision. Zhu et al[41] developed a CDSS applied to heart failure management which includes various reporting tools to help data tracking and analysis to be used by physicians (tabular view of medications, interactive trending graphs for weight tracking over time, and charts to support visual symptom analysis).

Effects of CDSSs on Malnutrition and Pressure Ulcer Prevention and Management

Seven articles[12,20–25] assessed the implementation of 5 different CDSSs to support pressure ulcer and malnutrition prevention and management (see Table 1). There is only 1 cluster RCT,[25] including 464 residents and 118 NH staff. The aim of the intervention is to assess the impact of the CDSS on nursing practice compliance with pressure ulcer prevention in NHs. A significantly increased number of patients (from 13.2% to 60.0% within 120 days, $P = .003$) actually received the recommended pressure ulcer prevention when there were seating in a chair. However, no effect was found on the allocation of preventive measures when residents at risk were lying in bed.[25] This study also reports a significant improvement in the attitude of health care professionals toward pressure ulcer prevention (from 74.3% to 83.5%, $P = .001$)[25]; however, no clinical outcome related to the decrease of pressure ulcer prevalence was found and no significant improvement

Table 1
CDSSs for Malnutrition and Pressure Ulcer Prevention and Management

Reference	Study Design	MMAT Rating	Residents (R), Facilities (F), and End-Users (U)	Clinical Outcomes	Process Outcomes	Other Outcomes
Olsho et al., 2014, USA[21]	Non-RCT	100%	- R = 3463 + 2698 - F = 12 + 13 - U = NA (Nurses)	- Significant reduction of pressure ulcer incidence (59% reduction in monthly incidence, $P = .035$)	- Not studied	- Cost saving ($20,800 per month per NH, 100 residents)
Fossum et al., 2011, Norway[12],*	Non-RCT	75%	- R = 491 - F = 15 - U = 28 (Nurses)	- Significant decrease of malnutrition prevalence (from 28.8% to 19.8%, $P = .05$) - No significant decrease of pressure ulcer prevalence	- Not studied	- Not studied
Beeckman et al., 2013, Belgium[25]	Cluster RCT	75%	- R = 464 - F = 4 - U = 118 (NH staff)	- No significant decrease of pressure ulcer prevalence	- Improved pressure ulcer prevention when residents are seated in a chair ($P = .003$) - No significant increase of pressure ulcer prevention when residents are lying in bed	- Significant improvement of the attitude of healthcare professionals toward pressure ulcer prevention ($P = .001$) - No significant improvement of health care professional knowledge
Fossum et al., 2013, Norway[24],*	Non-RCT	75%	- R = 971 - F = 15 - U = NA (Nurses)	- Not studied	- Improved documentation of pressure ulcer (from 25% to 88%) and nutritional status nursing assessment (from 20% to 100%)	- Not studied
Yap et al., 2019, USA[22]	Observational study (pre/post design)	100%	- R = 44 - F = 1 - U = 38 (Nurses)	- Not studied	- Significant improvement of compliance with repositioning clinical practice guidelines ($P = .0003$)	- Improved communication and professional commitment ($P = .035$) - Satisfaction with the CDSS implementation (focus groups) - No improvement of nursing culture
Fossum et al., 2011, Norway[23],*	Observational study (cohort)	100%	- R = NA - F = 15 - U = 25 (Nurses)	- Not studied	- Not studied	- Ease of use, usefulness, and supportive work environment - Lack of training, resistance to using digital tools, limited integration of the CDSS within the EHR, poorly designed graphical user interfaces
Sharkey et al., 2013, USA[20]	Observational study (cross-sectional)	100%	- R = 2102 - F = 14 - U = NA (NH staff)	- Not studied	- Not studied	- High level of CDSS use for pressure ulcer prevention in 36% of NHs - Significant involvement of NH directors and high participation of nurse managers

*The 3 studies by Fossum et al. used the same CDSS but were focused on different assessment facets.

was observed in health care professional knowledge,[25] as assessed by a validated pressure ulcer Knowledge Assessment Tool.[44]

Three studies are non-RCTs,[12,21,24] including 7623 residents and 28 nurses. Clinical outcomes are assessed in 2 studies. In these studies, using the CDSS significantly lowered the prevalence of malnutrition among NH residents (from 28.8% to 19.8%, $P = .05$)[12] and significantly decreased pressure ulcer incidence (59% reduction in a month, $P = .035$).[21] Cost reduction (approximately US$208 saved per month and per resident) was also observed.[21] The third study concludes on the better documentation of nurse assessment of pressure ulcers (from 25% to 88%, $P < .05$) and nutritional issues (from 20% to 100%, $P = .007$)[24] in patient records when using the CDSS.

The 3 remaining studies are observational studies,[20,22,23] involving 2146 residents and 63 nurses in total. The use of the CDSS was associated with an improvement of care delivery, for example, a better compliance of nursing care with repositioning clinical practice guidelines (from 7.0% to 100% during a 3-day baseline period and from 50.6% to 100% during the 18-day intervention $P = .0003$).[22] However, no significant change in nursing culture (assessed by the Nursing Culture assessment tool[45]) was reported.[22]

Effects of CDSSs on Drug Prescription and Medication Review

Drug prescription

The implementation of CDSSs supporting daily drug prescription is described in 8 studies[26–33] that report the results of the assessment of 8 different CDSSs (see Table 2). Six studies enroll physicians as primary users of the CDSS.[26–33] Pharmacists are the principal users in the 2 other studies.[27,30]

Four studies are cluster RCTs,[26,29–31] including 3209 residents with physicians and pharmacists as users. No clinical outcomes are reported in these studies. Gurwitz et al[30] observed no significant reduction of ADEs or preventable ADEs. The other cluster RCTs reported an improvement of drug prescribing in response to alerts generated by the CDSS. Judge et al[31] observed that alerts were most likely to generate appropriate action, for example, ordering a recommended laboratory test or canceling an inappropriate ordered drug (25% with the CDSS vs 7% in the control unit, relative risk 1.11, 95% confidence interval 1.00–1.22). Donovan et al[29] reported that psychotropic medication orders, modified in response to alerts, were significantly improved. Final drug orders were appropriate

Table 2
CDSSs for Daily Drug Prescription

Reference	Study Design	MMAT Rating	Residents (R), Facilities (F), and End-Users (U)	Clinical Outcomes	Process Outcomes	Other Outcomes
Papaioannou et al., 2010, Canada[27]	Observational study (pre/post design and focus groups)	75%	- R = 128 - F = 6 - U = 12 (NH staff, pharmacist)	- No significant increase of the percentage of INR in the therapeutic range	- Significant decrease of the average number of INR tests per month ($P < .0001$)	- Decreased workload, improved health care professional confidence in patient management and drug decisions, improved teamwork, improved communication
Gurwitz et al., 2008, USA[30]	Cluster RCT	100%	- R = 1118 - F = 2 - U = NA (Pharmacists, physicians)	- No significant decrease of ADEs and preventable ADEs	- Not studied	- Not studied
Judge et al., 2006, USA[31]	Cluster RCT	75%	- R = 445 - F = 1 - U = NA (Physicians)	- Not studied	- Alerts were more likely to engender an appropriate action such as ordering a recommended laboratory test or canceling an ordered drug (RR = 1.11, 95% CI = 1.00– 1.22)	- Not studied
Handler et al., 2008, USA[32]	Observational study (cohort)	75%	- R = 274 - F = 1 - U = NA (Physicians)	- Not studied	- ADEs detected in NHs with a high degree of accuracy using a clinical event monitor. - Overall PPV for all signals = 81% - Of the true positive findings, one-third of ADEs considered as preventable. - Of the preventable ADEs, 88% occurred at the monitoring and 69% at the prescribing stages.	- Not studied

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Table 2 (*continued*)

Reference	Study Design	MMAT Rating	Residents (R), Facilities (F), and End-Users (U)	Clinical Outcomes	Process Outcomes	Other Outcomes
Field et al., 2009, Canada[26]	Cluster RCT	100%	- R = 833 - F = 1 (22 units) - U = NA (Physicians)	- Not studied	- Higher proportions of final drug orders were appropriate in the intervention units (RR = 2.4, 95% CI = 1.4–4.4 for maximum frequency; RR = 2.6, 95% CI = 1.4–5.0 for drugs that should be avoided; and RR = 1.8, 95% CI = 1.1–3.4 for alerts to acquire missing information). - Final drug orders were appropriate significantly more often in the intervention units (RR = 1.2, 95% CI = 1.0–1.4) - No improvement of drug orders with appropriate doses (eg, no dose adaptation for residents with renal insufficiency)	
Donovan et al., 2010, USA[29]	Cluster randomized trial	50%	- R = 813 - F = NA - U = NA (Physicians)	- Not studied	- Significant improvement of psychotropic medication orders in response to alerts (8% in intervention unit vs 2% in control unit, RR = 3.69, 95% CI = 1.08–12.57) - No overall improvement of prescribing quality	- Not studied
Kennedy et al., 2011, Canada[28]	Observational study (cohort)	50%	- R = 1196 - F = 7 - U = 5 (Physicians)	- Not studied	- Physicians responded to 70% of the alerts with a dose change or medication discontinuation.	- Alerts considered as helpful
Subramanian et al., 2012, USA[33]	Ancillary study in a cluster randomized trial	25%	- R = NA - F = 1 - U = 10 (Physicians)	- Not studied	- Not studied	- Modest reduction of direct costs by US$1391, net 7.6% for 12 months

CI, confidence interval; PPV, positive predictive value; RR, relative risk; NA, not available.

significantly more often in the intervention units as reported by Field et al[26] (increase of recommended administration frequencies, but no improvement of the appropriate doses, and decrease of drugs that were recommended to avoid in NHs). However, Donovan et al[29] found no overall improvement of the quality of psychotropic medication prescriptions with the use of a CDSS.

Three studies are observational studies,[27,28,32] including 1598 residents and 17 users. Papaioannou et al[27] reported no significant increase of the percentage of international normalized ratio (INR) in the therapeutic range for resident on warfarin. However, CDSSs supporting daily drug prescription showed an impact on practices beyond clinical outcomes. Handler et al[32] implemented a clinical event monitoring system using signals to detect potential ADEs that allowed improvement in the detection of ADEs at levels that are substantially higher than the rates reported in the literature (53% for antidote signals and 96% for laboratory/medication signals). Papaioannou et al[27] showed that using a CDSS significantly decreased the average number of INR tests performed per month (from 4.2 to 3.1 per resident,

$P < .0001$), while at the same time either maintaining or improving the quality of warfarin management. Similarly, Kennedy et al.[28] reported that physicians responded to 70% of the alerts with an appropriate dose change or medication discontinuation when using the CDSS.

The last study is an ancillary study performed in a cluster randomized trial[33] studying 10 users that concluded on a modest reduction of costs (US$4.71 per resident and per year) partially offset by an increase in laboratory-related costs.[33]

Medication review

Six studies[34–39] evaluate the role of CDSSs to improve medication review (see Table 3). None of them evaluate CDSS clinical outcomes. One cluster RCT,[34] including 141 residents and 60 pharmacists and physicians, showed an improved physicians' assessment of the importance and performance of consultant pharmacists services. In this study, importance rating increased for all 24 survey questions, and 5 of the changes were statistically significant ($P < .05$).

One non-randomized trial,[37] including 54 residents and 14 nurses describes a CDSS to be used by nurses to initiate and prepare medication reviews.[37] CDSS detected significantly more drug-related issues ($P = .008$) than nurses, but nurses detected additional relevant problems that were outside the scope of the CDSS (eg, the lack of adherence). In addition, CDSS allowed improvement in the quality of prescriptions with a decreased number of renally excreted drug orders in residents with reduced renal function.

The 4 remaining studies are observational studies,[35,36,38,39] including 1425 residents and 36 users (12 physicians and pharmacist and 24 nurses). Using a CDSS evidenced some positive outcomes on care delivery processes. Ulfvarson et al[35] reported that the CDSS improved the quality of drug use with the reduction or the elimination of dangerous or improper prescriptions (reduction of anticholinergic drugs by 40%, of long-acting benzodiazepines by 17%, correction of drug duplication by 30%). When using the system to support medication review, the number of drugs used decreased from 10.4 to 9.5 drugs per patient, resulting in a more cost-effective drug therapy (decreased drug costs of 149 euros per patient over a 10-month period), while preserving the same level of care quality. De Wit et al[39] studied the relevance of alerts generated by the CDSS and reported that only 3.6% of alerts were considered as clinically relevant, with nonrelevant alerts related to care already delivered.

Table 3
CDSSs for Medication Review

Reference	Study Design	MMAT Rating	Residents(R), Facilities (F), and End-Users (U)	Clinical Outcomes	Process Outcomes	Other Outcomes
Ulfvarson et al., 2010, Sweden[35]	Observational study (pre/post design)	75%	- R = 275 - F = 7 - U = 12 (Physicians)	- Not studied	- Improved quality of drug use: reduction of anticholinergic drugs (40%), long-acting benzodiazepines (17%), drug duplication (30%), drugs that should be avoided in patients with impaired kidney function (17%), number of drugs per patient (from 10.4 to 9.5)	- Increased teamwork and awareness of the importance of detecting ADEs - Cost saving (143 € per patient/ 10 months)
Johansson-Pajala et al., 2018, Sweden[37],[*]	Non-randomized trial (pre/post design)	100%	- R = 54 - F = 4 - U = 14 (Nurses)	- Not studied	- Improved detection of ADEs such as adverse drug reactions (27 vs 43, $P = .000$) and drug-drug interaction (10 vs 22, $P = .008$) - Decreased use of renally excreted drugs in residents with reduced renal function (92.1% vs 86.8%)	- Not studied
De Wit et al., 2015, The Netherlands[39]	Observational study (cohort)	50%	- R = 900 - F = 1 - U = NA (Pharmacist, physicians)	- Not studied	- Not studied	- Alert fatigue due to non-clinically relevant alerts - Unnecessary alerts related to care already delivered but not documented in patient records

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Table 3 (*continued*)

Reference	Study Design	MMAT Rating	Residents(R), Facilities (F), and End-Users (U)	Clinical Outcomes	Process Outcomes	Other Outcomes
Kane-Gill et al., 2016, USA[34]	Cluster RCT	50%	- R = 141 - F = 4 - U = 60 (Pharmacists, physicians)	- Not studied	- Not studied	- Improved physicians' assessment of the importance and performance of consultant pharmacist services
Johansson-Pajala et al., 2017, Sweden[36,*]	Observational study (qualitative method)	100%	- R = 250 - F = 4 - U = 16 (Nurses)	- Not studied	- Not studied	- Nurses' expectations from CDSSs include time saving, clinical work standardization, knowledge acquisition, and a better division of responsibilities between nurses and physicians
Johansson-Pajala et al., 2019, Sweden[38,*]	Observational study (qualitative method)	75%	- R = NA - F = 2 - U = 8 (Nurses)	- Not studied	- Not studied	- Nurses' recommendations for a positive CDSS implementation include time saving, curbing administrative hassle, improved collaboration at all levels, identifying responsibilities and roles, and governance involvement

*The 3 studies by Johansson-Pajala et al. used the same CDSS but were focused on different assessment facets.

Effects of CDSSs on Disease Management

Disease management was applied to heart failure, falls, and chronic diseases (eg, Alzheimer disease). Results are displayed in Table 4. Three studies assess the use of a CDSS for disease management in NHs.[40–42] All 3 studies are observational studies and describe 3 different systems cumulating 783 residents and 47 NH staff.

No study involving the use of a CDSS for disease management evaluated the impact of the system on patient clinical outcomes. However, the OneTouch system[40] that automatically triggers clinical alerts to support identifying when a resident might be experiencing some change in condition (eg, constipation, dehydration, skin integrity change, weight loss, weight gain) was beneficial in decreasing pressure ulcer prevalence (from 20% to 9%) and pain (from 14% to 6%) as a side effect. Process outcomes were assessed in the 2 other studies.[41,42] Colón-Emeric et al[42] showed that using a guideline-based CDSS applied to the management of 5 common problems in NHs (falls, fever, pneumonia, urinary tract infection, and osteoporosis) could improve the collection of quality measures for blood pressure (from 17.5% to 30.0%, $P = .29$), neuroleptic prescription (from 53.8% to 75%, $P = .27$), sedative-hypnotics prescription (from 16.7% to 50.0%, $P = .50$), calcium prescription (from 22.5% to 32.5%, $P = .45$), vitamin D prescription (from 20.0% to 35.0%, $P = .21$), and external hip protectors (from 25.0% to 47.5%, $P = .06$). Zhu et al[41] developed a CDSS following the heart failure national guidelines for the weekly monitoring, evaluation, and management of care for patients suffering from heart failure. This included documentation of left ventricular function, weight changes, and specific symptoms tracking, medication titration, discharge instructions, 7-day follow-up appointment post NH discharge, and patient education. Using the CDSS showed to have beneficial process outcomes, for example, the authors observed that data capture was improved as compared with paper-based practices, and order input was enhanced (auto completion of medication name, easy retrieval of medication history, easy medication modification).[41] Besides, Zhu et al[41] reported that real-time data capture when using the CDSS was beneficial to avoid errors and allowed time savings by the automatic computation of clinical scores.

CDSS Users' Acceptance

Users' acceptance of CDSSs was rarely investigated in the retrieved studies,[22,23,27–29,35,39–42] and when investigated, results were controversial.

A good acceptance of the CDSS was reported in 6 studies[22,23,27,28,35,40] where users considered that the CDSS was a supportive work environment tool, easy to use, and useful.[23,28] In a survey, Papaioannou et al.[27] reported CDSS users thought the CDSS decreased workload (75% of participants), improved health care professional confidence in patient management and drug decisions (80% of participants), and enhanced teamwork (67% of participants) and communication (92% of participants). Ulfvarson et al[35] reported the same conclusion that users considered the CDSS was successful to improve teamwork between health care professionals.

However, 5 studies[23,29,39,40,42] reported a poor acceptance of CDSS users. Fossum et al[23] observed some resistance to using computers and a limited integration of the CDSS within the facility's EHR. Alexander et al[40] reported multiple unnecessary alerts due to the non-documentation of actually given care, criticism expressed toward the lack of standardization in terminologies,[40] and a poor use of the CDSS by NH staff except for the management of falls (in 73% of the cases), although the system was recognized as a means to improve the training of new staff.[42] Similarly, de Wit et al[39] highlighted the alert

Table 4
CDSSs for Disease Management

Reference	Study Design	MMAT Rating	Residents (R), Facilities (F), and End-users (U)	Clinical Outcomes	Process Outcomes	Other Outcomes
Alexander, 2008, USA[40]	Observational study (pre/post design)	50%	- R = 518 - F = 3 - U = NA (NH Staff)	- Decreased prevalence of pressure ulcers (from 20% to 9%) and pain (from 14% to 6%)	- Not studied	- Moderate adoption of the CDSS - Unnecessary alerts related to care already delivered but not documented in patient records - Staff frustration because of the lack of standardization in terminologies
Colón-Emeric et al., 2009, USA[42]	Observational study (pre/post design)	100%	- R = 265 - F = 2 - U = 42 (NH staff)	- Not studied	- Improved collection of quality measures (from 17% to 30%)	- Easy training of new staff - CDSS infrequently used except for falls (73%)
Zhu et al., 2017, USA[41]	Observational study (cohort)	25%	- R = NA - F = NA - U = 5 (NH staff)	- Not studied	- Improved data capture as compared to paper-based practices - Enhanced order input - Errors avoided and time saved (automatic computing of clinical scores)	- Not studied

fatigue phenomenon with only 3.6% of alerts considered as actually clinically relevant.

Qualitative methods have been used to assess nurses' position toward the use of CDSSs. Nurses' expectations stated that the CDSS should help saving time, provide some clinical work standardization, support knowledge acquisition, and contribute to a better division of responsibilities between nurses and physicians.[36] Nurses' recommendations for a successful CDSS implementation were that the CDSS should save time, curb administrative hassle, improve collaboration at all levels, and identify responsibilities and roles. There should also be a strong governance involvement.[38]

The use of CDSSs in routine practice was not described in the selected articles, thus CDSS adoption beyond the intervention study period is not discussed in this article.

Discussion

Despite an exhaustive search, the scoping review identified only 24 studies reporting on the use of a CDSS in NHs, among which only 6 are controlled trials. This low number contrasts with those of literature reviews on CDSSs that did not restrict to NHs. For instance, with respect to CDSS impact, Bright et al,[46] in 2012, included 148 RCTs, Roshanov et al,[10] in 2013, included 162 RCTs, and more recently in 2020, Kwan et al[47] analyzed 108 randomized or quasi-randomized trials. Such an imbalance confirms that NH CDSSs still have been poorly investigated, meaning that probably CDSSs are implemented less often in NHs than in other health care settings, and that evidence regarding current CDSS impact in NHs would be less robust. In our study, only 4 RCTs reported a positive impact of the CDSS on care delivery concerning the prevention of pressure ulcers and ADEs.

Besides, included articles are rather old, published before 2015, except those used to support medication review. Most of the selected articles (58%) are applied to drug prescription and reviewing. This can be explained by the fact that older adults are subject to multimorbidities and polymedication, and consequently very likely to experience ADEs.[48] The other studies are mainly applied to the management of pressure ulcers and malnutrition, with a few of them applied to disease management.

These findings about the relatively scarce literature and the focus on medication are broadly consistent with those of other published reviews on the subject. Thus, a recent systematic review and meta-analysis of RCTs assessing interventions that increase the appropriateness of medications used in NHs retrieved only 2 interventions, including a CDSS.[49] In 2015, Marasinghe[50] published a systematic review on CDSSs in long-term care homes, but the focus, restricted to medication safety, was not as broad as in this scoping review. Only 7 articles met the inclusion criteria, leading the author to the conclusion of limited literature on the subject. It is of note that among the 7 studies selected by Marasinghe,[50] 6 reported on CDSSs for daily drug prescription[26,28–32] that we also retrieved and included within our review. The seventh article was not related to NHs but to adults aged 65 and older.

The impact of CDSSs in terms of clinical outcomes for NH residents was assessed in only one-quarter of all studies.[12,21,25,27,30,40] Three of them reported positive effects: a decrease in malnutrition prevalence,[12] a decrease in pressure ulcer incidence,[21] and a decrease of pain prevalence.[40] Two studies reported no impact of the CDSS on pressure ulcer prevalence,[12,25] and 1 study showed no impact on the reduction of ADEs.[30] From this limited number of studies, the impact of CDSSs on residents' clinical outcomes appears to be poorly studied and, when studied, it remains limited.[9] Otherwise, improvements of care delivery were observed in almost all included studies.[22,24–29,31,32,35,37,41,42] The benefits reported are similar to those already observed in hospital settings,[51] for example, improvement of drug order quality, better compliance with guidelines (for pressure ulcer prevention), and enhanced documentation of care records. In addition, studies showed that CDSSs were useful and cost-effective[21,33,35]; they allowed for time saving, they improved communication and health care professional commitment,[22] and they increased teamwork.[33,35] However, no improvement of health care professional knowledge[25] or nursing culture[22] was reported.

It should be noticed that almost all systems were evaluated by their own developers and it has been reported that such evaluations are more likely to show benefit than evaluations conducted by third parties.[10] Moreover, most CDSSs were embedded within an EHR or a CPOE system. This allows for system interoperability, unique data entry, multiple data reuse, and enables workflow integration, characteristics that are known to increase users' acceptance and CDSS use as compared with standalone CDSSs.[10]

CDSSs are generally poorly described in the studies retrieved by the scoping review and it is difficult to know how these systems were developed (eg, guideline modeling, knowledge base implementation, data processing, users' interfaces) and how they were operating. Kawamoto et al[11] attempted to address the question of which CDSS features contribute to making them more effective in a meta-analysis of 70 studies. In particular, they stressed the importance of a decision support recommendation accompanying warnings rather than a simple assessment or alert. Lobach et al[52] pointed out that when CDSSs did not require the entry of new information, they were more likely to be adopted. However, CDSS limits, such as alert fatigue, distraction, or user hostility, have been reported.[53] The main pitfalls of issuing too many clinically nonrelevant alerts are a systematic overriding, CDSS disconnection, or clinician burnout.[54] In our work, NH users' acceptance, when assessed, was judged satisfactory, although alert fatigue was explicitly reported in 2 studies.[39,40] Finally, the small number of studies and the diversity of CDSSs and of study designs made difficult the identification of factors contributing to the adoption of CDSSs specifically designed for NHs.

As with any literature review, this scoping review presents some limitations related to publication bias: some studies reporting on the implementation of a CDSS in NHs may have not been published, especially if the results were negative. Another potential limitation is that the studies we found are heterogeneous, and we have gathered them by type of clinical application to identify general trends in their effects. The methodological design and quality of the studies were also heterogeneous. We chose not to exclude any studies because of poor methodological scores, as studies evaluating CDSSs are much more difficult to conduct than traditional double-blind drug evaluation.

Conclusions and Implications

We performed a scoping review of the literature to identify studies of CDSSs implemented in NHs and assess CDSS factors impacting NH resident clinical outcomes and care delivery. Whether embedded within an EHR or not, used by physicians, nurses, or pharmacists, generating alerts or not, this review suggests CDSSs may improve health care professional daily practice and resident clinical outcomes in several domains, especially pressure ulcer prevention and drug prescription improvement. However, we could not draw robust conclusions from the evidence reported in the studies retrieved due to the variability in CDSS design, intervention protocols, outcomes, and the limited number of included studies. Therefore, more good-quality studies are needed to assess further initiatives such as the deployment of CDSSs able to detect critical conditions, alert practitioners during care processing, provide recommendations to make decisions easier, or simply remind of actions not-to-be missed, all functionalities being rather promising in the NH context. Besides, CDSS effects on residents' clinical outcomes should be more extensively investigated in future studies.

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Supplementary Data

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