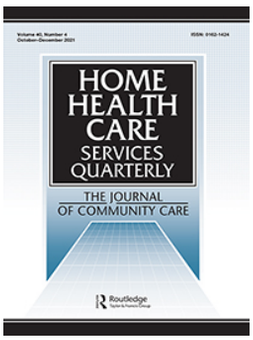

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Medication errors and processes to reduce them in care homes in the United Kingdom: a scoping review

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ABSTRACT

Medicines-related incidents are a leading cause of preventable harm across all patient groups, including care home residents. Despite national guidance, there is little information on assessing medication error rates and evaluating changes to reduce them. This review explored the scientific and gray literature on medicine-related incidents, causation and evaluation of changes in care homes in the United Kingdom. The research identified 2951 documents, 32 analyzed; some of them covered more than one area. Seven reported rate and causes, eleven causes, eleven made recommendations, and four reported the evaluation of changes to processes and systems. Three areas emerged; 1) medicine-related incident rates ranged between 1% and 38%, 2) incident rates increased where formulations were not tablets or capsules ranging from 12% to 50% depending on the formulation, 3) three evaluations of changes aimed at reducing medicine incidents. Therefore, information on medicine-related incidents in care homes is available, but not systematically described.

Keywords
Medicines; errors; incidents; car homes

Introduction

The World Health Organisation (WHO), (2017) stated that "*unsafe medication practices and medication errors are a leading cause of injury and avoidable harm in health care systems across the world.*" The WHO cited a review by Lehnbom, Stewart, Manias, and Westbrook (2014) who concluded "*medication reconciliation identified unintentional medication discrepancies in 3.4% to 98.2% of patients.*" In 2017, the WHO identified "*medication without harm*" as the theme for the third Global Patient Safety Challenge (World Health Organisation, 2017). Care Inspectorate Wales (Scotland), Regulation and Quality Improvement Authority (Northern Ireland) and Care Quality Commission (England) have regulatory responsibility for the use of medicines within care homes across the United Kingdom. Between 2018 and 2019 each regulator published qualitative or quantitative data relating to the use of medicines within care homes. In chronological order, in England inspections where enforcement action was taken, described in the Care Quality Commission CQC State of Care report (Care Quality

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Commission, 2018) included: "*issues with documentation, for example, medication dosages and strengths and timings not being accurately recorded*." The concepts of medication dosages, strengths and administration times are linked to medication management and medicine optimization. The Regulation and Quality Improvement Authority (RQIA) (Regulation and Quality Improvement Authority/National Institute for Health and Care Excellence, 2018) in Northern Ireland, reported the receipt of 659 medicines-related incidents notifications between 2017 and 2018. In Wales, a joint report published by Care Inspectorate Wales (CIW) and Health Improvement Wales highlighted care home staff concerns about the quality of hospital discharges (Care Inspectorate Wales; Healthcare Inspectorate Wales, 2018). Key issues raised by care home staff included "*medication was not provided with the resident, information around dosing was missing or that the wrong medication was provided*." Whilst Care Inspectorate (CI) in 2019, published a statistical bulletin that highlighted that 50 complaints were upheld concerning the use of medicines within care homes representing 6.5% of upheld complaints in care homes (Care Inspectorate, 2019).

In 2013, the Royal Pharmaceutical Society suggested medicine management aims at optimizing the medicines processes and systems, whilst medicines optimization focusses on the outcomes and the patients' perspective (Royal Pharmaceutical Society, 2013). The reports and data published by the four UK regulators of care home services indicated that whilst best practice guidance (Care Inspectorate, 2012; National Institute for Health and Care Excellence, 2014, 2015) had been published, medicine-related incidents continued to occur.

Therefore, a scoping review was undertaken to systematically map the available information and research in this area and identify any existing gaps in knowledge or application of best practice. Munn et al. (2018) suggested that the objectives of a scoping review are to identify the types of evidence, to examine how the research was conducted, to clarify concepts and definitions and to identify and analyze knowledge gaps.

The key research questions were:

What is the available information on care homes in the United Kingdom regarding:

(1) Medicines-related incidents?
(2) Incident causation?
(3) Evaluation of changes and processes?

Method

Scoping review

A scoping review methodology (Arksey & O'Malley, 2005; Levac, Colquhoun, & O'Brien, 2010) was adopted in response to the research questions. The first five stages described by Arksey and O'Malley (2005) and Levac et al. (2010)

were utilized. The use of this framework allowed the identification of the research questions and the research strategy that enabled the identification of the relevant documents. The Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Tricco et al. (2018) was utilized during study reporting.

Development of the research question included a search of the Cochrane Database and PubMed for existing scoping and systematic reviews. Whilst no relevant reviews were identified, Care Home Use of Medicines Study (CHUMS) published in 2008 (Alldred, Barber, & Buckle et al., 2008) was identified as a significant paper. Therefore, 2006 was a pragmatic starting point for the search timeframe to identify papers published whilst the CHUMS paper was being written.

Eligibility criteria

Documents published in the English language from January 2006 to January 2021, related to medicine-errors were eligible for inclusion. These included medicine-error rates, causes, improvement programs and medicine audits attributable to care homes in the UK. Documents included: peer-reviewed papers, peer reviewed conference abstracts and gray literature as defined by Adams et al. (2016).

The documents excluded were those not published in the English language or conducted outside of the UK; research articles, focussed on the management of specific medicines or class of medicines or not matching the definition of gray literature.

Search strategy

To ensure breadth, depth and to avoid missing relevant documents, comprehensive systematic parallel searches were undertaken using the predefined concepts of medicine, care home, errors and learning or improvement. These included the search terms found in Table 1. Searches of Excerpta Medical Database (Embase), Management Information Consortium (HMIC) and Scopus were undertaken in accordance with PRISMA-ScR (Tricco et al., 2018).

Internet searches of websites of UK regulators and organizations concerned with care homes and social care were undertaken (CQC, CI, CIW, RQIA, National Care Forum, Joseph Rowntree, Foundation). The most recent search was completed in January 2021.

Further searches were conducted of bibliographies of selected publications. For completeness, this process was followed by a comparison of the title and keywords of included publications against the search terms found in Table 1. Appendix A contains the search strategy executed in Embase.

Table 1. Search terms.

Concept	Search Terms
(1) Medicine	(medication? OR "drug? Therapy" OR "drug? Administration" OR "drug? Therapy" OR "drug or medicinal products" OR prescribing)
(2) Care home	("care home" OR "nursing home" OR "residential home" OR "home care" OR "residential care" OR "residential services" OR "residential facilities")
(3) Errors	(error? Or incident? Or safety or accident? Or "medication? error?")
(4) Learning or improvement	(audit OR learning OR improvement OR evaluation OR "quality of healthcare" OR "quality of social care" OR "health care quality" OR "clinical audit" OR "medical audit" OR "quality assurance")

Study selection

The results from the electronic databases were exported to Excel 2010 365 (MS Office, One Microsoft Way, Redmond, WA, USA). Initial screening was undertaken to remove duplicates and non-UK publications. Further screening cycles by title, abstract and full text were undertaken by the first author (MI). Documents were categorized as; "Yes" (meeting the inclusion criteria, but not the exclusion criteria), "No" (Meeting the exclusion criteria or not meeting the inclusion criteria) or "Maybe." Articles categorized as "Yes" and "Maybe" were taken forward to the next screening stage.

Data collection

A bespoke data collection form was developed using an inductive approach that was then used for data extraction. The extracted data comprised study authors, methods including location, care and or nursing homes, stated outcomes, measures or results/findings, sample sizes, durations, results, and limitations; the first author (MI) completed the data extraction forms.

Study quality assessment

A "risk of bias" assessment was optional according to the PRISMA-ScR checklist. However, due to the range of documents identified, critical appraisal of the included documents was undertaken using the specific critical appraisal skills program Critical Appraisal Skills Programme, , 2018) checklist, according to the study design. The gray literature was appraised using the closest matching CASP checklist as suggested within library guides published by the University of Canberra (Appraisal (The AACODS Checklist) – Grey Literature in Health).

Synthesis of results

Deductive and inductive approaches were applied to group the identified documents by both how the documents were developed, and the conclusions drawn within the documents. These included the context-mechanism-outcomes (CMO) contained within the documents as summarized by Jagosh (2019). The CMO approach provides a framework for realist causal explanation and was used in this review to identify the elements that trigger or hinder the mechanism.

Results

Study selection

The initial database search identified 2933 records, and further 18 records were identified via other search processes. Initial screening removed 423 duplicate documents and 2221 non-United Kingdom documents. Screening by title removed 228 and abstract 35. A further 12 were excluded following a full-text review resulting in 32 documents for inclusion. Figure 1 shows the article selection process.

Study characteristics

The included documents (n = 32) are summarized in Table 2. The development and evaluation of a care home charter for swallowing and medicines was described in three documents (Smithard et al., 2019; The Patients Association, 2018; Wright, Hollowey, & Matala, 2018). Whilst NICE published guidance National Institute for Health and Care Excellence (2014) and a quality standard National Institute for Health and Care Excellence (2015) concerning Managing medicines in care homes. Therefore, whilst separately referenced, these two sets of documents were considered as two single documents by the authors.

The documents identified through the search strategy included multiple types including eleven full-text articles (original peer reviewed papers), nine conference abstracts, 12 classified as others including posters and publications from regulatory bodies, best practice organizations, working groups with patient, provider, and regulator representatives (Figure 1, see flow chart).

The closest matching CASP analysis was used to describe the study type and assess the quality of the paper irrespective of publication route. Eighteen documents were assessed using the qualitative cohort tool (Al-Hamadania et al., 2016; Alldred et al., 2015, 2008, 2011, 2010; Barber et al., 2009; Care Inspectorate, 2020; Cheng et al., 2019; Gilmartin-Thomas et al., 2017; Lang et al., 2017; Marshall, 2018; Patel & Donyai, 2013; Rivers et al., 2014; Sach et al., 2015; Santos Serrano et al., 2016; Swift, 2018; Szczepura et al., 2011; Wild et al.,

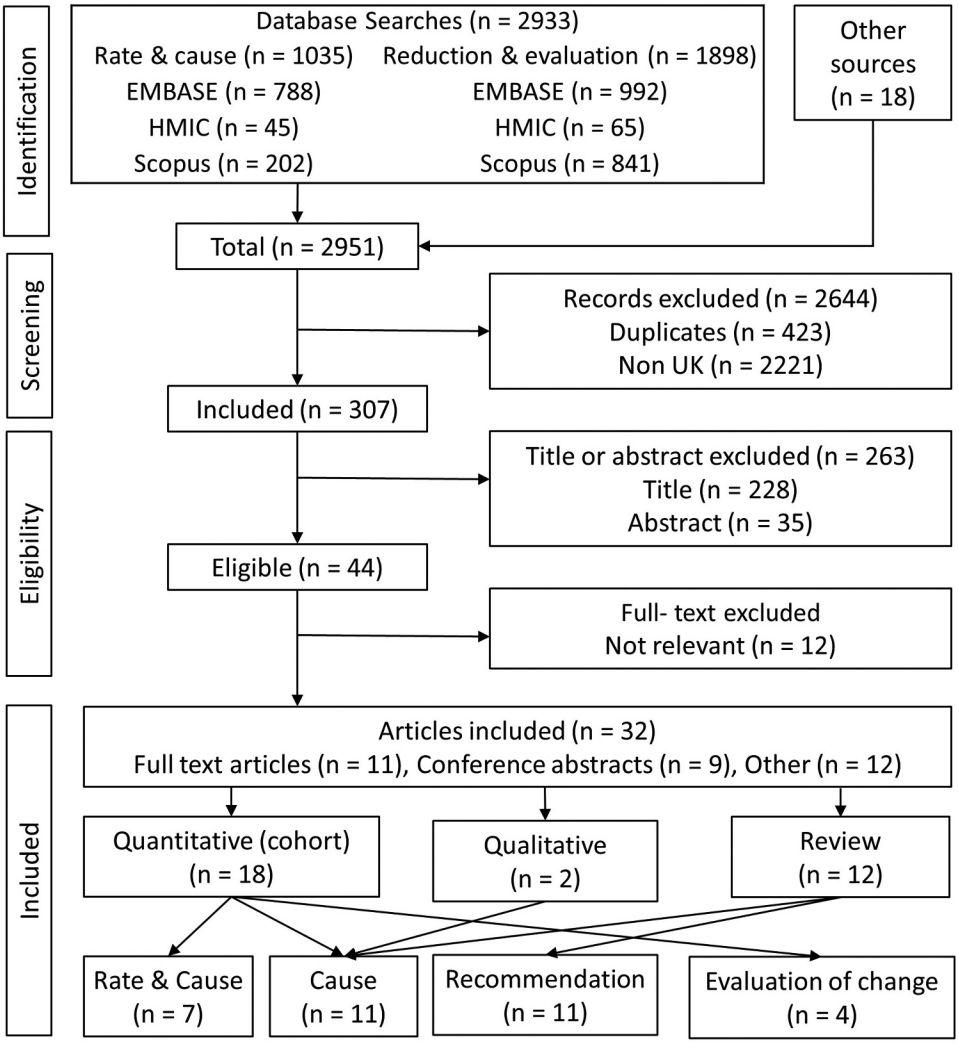

Figure 1. PRISMA flow diagram

2011) two documents were assessed using the qualitative tool (Akhtar et al., 2015; Lim et al., 2016) and the remaining 12 were assessed utilizing the review tool (Care Commission, Mental Welfare Commissoion for Scotland, 2009; Care Inspectorate, 2012; Care Quality Commission, 2019; Commission for Social Care Inspection, 2006; Gunnell et al., 2020; Joseph Rowntree Foundation, 2008; National Institute for Health and Care Excellence, 2014; National Care Forum, 2013; National Institute for Health and Care Excellence, 2015; Smithard et al., 2019; Szczepura et al., 2008; The AHSN Network, 2020; The Health Foundation, 2011; The Patients Association, 2018; Wright et al., 2018). (Figure 1 and Figure 2). The documents assessed using the qualitative

Table 2. Characterization of papers.

Year & Author	Country	Type	Method	Sample	Outcome
Rate and Cause					
Gilmartin-Thomas, Smith, Wolfe, and Jani (2017)	England	B	Observation of medicines administration round	10 services 823 residents	Errors per administered 178/2493 (7.1%) • OP with MCA 45/342 (13.2%) • MCA with OP 33/1073 (3.1%) • MCA & OP 78/1415 (5.5%) • Only OP 86/1064 (8.1%)
Al-Hamadania, Mantzourania, Smitha, and Delyth (2016)	Wales	U	Retrospective review of 1 cycle of medicines administration records	11 services 287 residents' records	Errors per resident • 7739/297 (26%) Proposed ergonomic system solutions: • Staffing levels and protection for medicines administration • Medicines trolley design • Building design • Improvements to communication and feedback loops between GPs, community pharmacies and care homes
Santos Serrano, Poland, Wright, and Longmore (2016)	England	N	Observed medicines administration round	6 services 166 residents	Errors per administered • 256/696 (36.7%) • 64/108 (dysphasic) • 174/586 (non-dysphasic)
Alldred et al. (2011)	England	B	Observation of medicines administration round	55 services 256 residents	Errors per administered by presentation: • MCA 31/732 (4.2%) • OP 28/404 (6.9%) • Liquid 20 /164 (12.2%) • Inhaler 26/52 (50.0%) • Topical, patch, injection 11/28 (39.3%)
Szczepura, Wild, and Nelson (2011)	England	B	Retrospective analysis of the conflict log within an eMAR	13 services 245 residents	Averted administration errors • 2289/18,829 (1.2%)
Barber et al. (2009)	England	B	Observation of medicines administration round	55 services 256 residents	Errors per administered • 116/1380 (8.4%)

(*Continued*)

Table 2. (Continued).

Year & Author	Country	Type	Method	Sample	Outcome
Alldred et al. (2008)	England	B	Observation of medicines administration round	55 services 256 residents	Errors per administered • 116/1380 (8.4%) Residents with errors • 57 /256 (22.3%)
Cause					
Gunnell, Pattni, White, Watts, and Kelly (2020)	England	B	Review of a sample of CQC reports rated inadequate	100 of 226 locations sampled	Top 4 medicines themes: • Medicine administration (85%), • Record keeping and assessment (85%) • Leadership (74%) • Risk management (74%)
Swift (2018)	England	B	Service Development programme	29 services	Areas of support provided included: • 20 Controlled drugs • 20 Documentation • 17 When required medicines
Lim, Anderson, and Buckle (2016)	England	N	To map medicines processes and medicines errors within the care home and its supply chain	7 care homes each with 27 to 55 residents	Recommendations made concerning: • Access and use of information • Record-keeping • Centralized records • Resident involvement
Sach, Desborough, Houghton, and Holland (2015)	Not stated	U	Comparative analysis of GP and care home records for appointments	362 paired services and GP records	• Substantial for GP, GP out of hrs and podiatrist • Moderate agreement for dietitian, paramedic & speech, and language therapist • Poor or slight agreement for chiropodist, music therapy, and social worker

(*Continued*)

Table 2. (Continued).

Year & Author	Country	Type	Method	Sample	Outcome
Alldred, Aslam, and Khan et al. (2015)	England	B	Postal survey of care homes about hospital discharge	61 from 208 (30%)	• Whilst 59 of 61 used MCAs only 2 received these on hospital discharge • Poor discharges (errors and omissions in dose, formulation, and quantity due to incomplete or illegible document)
Akhtar et al. (2015)	Scotland	U	Quality Improvement programme		Improved labels for 'when required' medicines
Rivers et al. (2014)	England	U	Postal survey of care home manager & staff about medicine error culture	124 from 800 care homes responded	• Nearly all staff agreed or strongly agreed with the statement "I feel confident that I am able to administer medicines correctly • Approximately 11% of staff agreed or strongly agreed with the statement 'I often feel stressed when administering medicines
Patel and Donyai (2013)	England	U	Postal survey of care home manager about community pharmacy services	16 from 60 responded (27%)	• 15 received printed MAR • 11 had enquiries answered • 9 advice on waste • 5 advice on policies
Wild, Szczepura, and Nelson (2011)	England	B	staff surveys undertaken pre- and post-staff training associated with the roll out of an e-MAR	13 services 49 staff	Medicines errors awareness increased • From 40% to 74% in care homes • From 0% to 83% in care homes with nursing

(*Continued*)

Table 2. (Continued).

Year & Author	Country	Type	Method	Sample	Outcome
Alldred et al. (2011)	England	B	Retrospective review of care home and GP medicines sensitivity records	31 services 121 residents	Residents with recorded sensitivities • 31 /121 (26%). Total sensitivities 48 • MAR 3/48 (6%) • Care record 29/48 (60%) • GP 35/48 (73%)
Alldred et al. (2008)	England	B	Observation of medicines administration round	55 services 256 residents	Proposed ergonomic system solutions: • Staffing levels • Medicines trolley design • Building design • Improvements to communication and between GPs, community pharmacies and care homes
Recommendations					
The AHSN Network (2020)	England	B	AHSN via patient safety collaboratives (PSC) engaged with the care home providers via an e-survey, workshops, and conversations		The sector would benefit from: • Quality Improvement training liked to problem areas • Work on safety cultures via Safety Champions and shared learning • Investment in digitization of care homes

(*Continued*)

Table 2. (Continued).

Year & Author	Country	Type	Method	Sample	Outcome
Care Quality Commission (2019)	England	B	Review of inspection reports, enforcement notices and statutory notifications	55 report 50 notices 405 notifications	Good practice: • Use of least restrictive practice prior to chemical restraint • Red bag scheme for transfer of care Poor: • Incorrect and missed doses • Lack of relevant detail in care plans • Poor security of medicines Recommendations • Adopt best practice
Smithard et al. (2019), Wright et al. (2018), The Patients Association (2018)	Not stated	B	Working group developed and published a charter for swallowing and medicines	9 services	Administration of medicines to consider: • Appropriates of the medicines formulation and route to the patients need • Ensuring oral health needs are met • Recognizing unsafe swallowing and acting appropriately 83% found the charter useful
National Institute for Health and Care Excellence (2014, 2015)	England, Wales	B	Evidence based recommendations and quality standards		Six auditable statements

(*Continued*)

Table 2. (Continued).

Year & Author	Country	Type	Method	Sample	Outcome
National Care Forum, (, 2013a, (2013b))	England	B	Summarization of four working groups	Evaluated by 82 care homes	Published toolbox covering: • Residents' charter • My record, my medicine, my choice • Leadership guide Learners' workbook and training guide for employers A set of tools for identifying residents with deteriorating symptoms and for using homely remedies, including: Symptom assessment tool, Homely remedies guide, Risk assessment tool
Care Inspectorate (2012)	Scotland	B	Guidance based on observations made by the inspection staff during inspections		Optimizing medicines administration records through: • Timings three times a day vs. specific times • Recording administration, refusal, not required etc. • Changes – new medicines, dose changes, stopping and finishing medicines, duplicates Optimizing medicines care plans • Individual and condition specific • Sufficient detail in when required medicines plans

(*Continued*)

Table 2. (Continued).

Year & Author	Country	Type	Method	Sample	Outcome
The Health Foundation (2011)	England	B	Summarization of testimony from family and carers of people living in care homes concerning the use of medicines.		• Communication and Information sharing • Prescribing and administration if medicines • Staff development and Support • Advocates and rights
Care Commission, Mental Welfare Commissoion for Scotland (2009)	Scotland	B	Review of inspection reports		Covert administration 20/1335 residents, very few had appropriate safeguards in place Problems on MARs include: • Duplicate entries • Tablet and liquid versions of the same medicines • Several preparations containing paracetamol
Joseph Rowntree Foundation (2008)	England	B	Selective summary of finding from a narrative literature review by Szczepura et al. (2008)		• Better management of medication • Pharmacist reviews of medicines can be beneficial. • Transfers of care between settings are important • However, there are gaps in the research
Szczepura et al. (2008)	England	B	Narrative literature review, 34 medicines and 113 quality improvement citations		• Medicines optimization can be improved in nursing homes, lack of evidence for care homes • Research is lacking on Inter-care home transfers

(*Continued*)

Table 2. (Continued).

Year & Author	Country	Type	Method	Sample	Outcome
Commission for Social Care Inspection (2006)	England	B	Review of noncompliance for medicines outcome in inspection reports and complaints		• Nearly half of care homes were not meeting the minimum standards for medicines • themes included: poor administration, training, or lack of records • 43.5% of complaints involving medicines were upheld
Evaluation of Change, Care Inspectorate (2020)	Scotland	U	Quality Improvement programme	10 services	Median errors per resident per week were reduced through: • Staff education • Use of regular agency staff • Daily medicine issues communication sheet • Review or when required medicines and color coding • Twice daily checking of topical medicines administration records • Review and discontinuation of old medicines
Cheng, Smith, & Gumbleton, 2019	UK	B	Retrospective analysis of the conflict log within an eMAR to explore nurses delegating administration of medicines to care staff	8 services 527 residents 99 nurses 64 care staff	7921 averted medicines errors • Median rate per resident 7 (inter quartile range 2–19) • Statistical analysis (Mann–Whitney U-test) showed no significant differences ($P > .05$) in the rates of potential incidents involving medicines by nurses or care workers

(*Continued*)

Table 2. (Continued).

Year & Author	Country	Type	Method	Sample	Outcome
Marshall (2018)	Scotland	U	Quality Improvement programme	1 service	Median error per resident per week was reduced following: • Tidying up the MAR charts • Triaging the need to replace dropped tablets • Staff increased escalating issues like pending out of stocks
Lang, Gulhane, Khoda Vyas, and Barnett (2017)	England	U	Evaluation of a service development to support transfer of care	15 complex discharges	Errors from complex discharges • 42/156 medicines (27%) • 42/15 (2.8 per resident, range 0 to 8)

Key: With and without nursing (B), Nursing only (N), Unspecified (U)
Multi Compartment Aid (MCA), Original pack (OP)

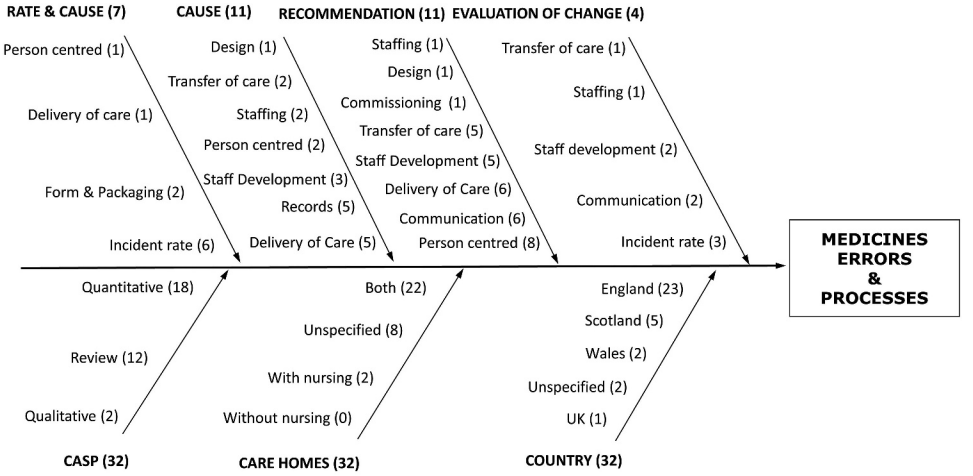

Figure 2. Fish bone diagram mapping the identified papers by type, service, country, outcome and theme

cohort tool all report one or more patient or service group. The two documents assessed using the qualitative tool described mapping of medicine processes within care homes and using quality improvement methodology to improve "when required" protocols. Documents that summarized other documents were assessed using the review tool.

The identified documents were either reporting studies undertaken within one or more of the home nations or directed toward people living and working within one or more of the home nations these were deductively coded as England (23), Scotland (5), Wales (2), unspecified (2), and UK (1).

The registered status of care home described within the document or were directed toward were coded as care homes (with and without nursing = both) (22), unspecified (8), with nursing (3) and without nursing (0).

Outcomes

Based on the study questions, the selected documents were deductively coded for outcomes as rates and causes, causes, recommendations, or evaluation of change concerning medicine-related incidents. Seven documents described the rate and causes of medicine-related incidents (Al-Hamadania et al., 2016; Alldred et al., 2008, 2011; Barber et al., 2009; Gilmartin-Thomas et al., 2017; Santos Serrano et al., 2016; Szczepura et al., 2011). Eleven documents described possible causes of medicines-related incidents (Akhtar et al., 2015; Alldred et al., 2015, 2008, 2010; Gunnell et al., 2020; Lim et al., 2016; Patel &

Table 3. Identified papers mapped by outcome and theme.

	Rates and causes (7)	Causes (11)	Recommendations (11)	Evaluation of change (4)
Commissioning (1)			Care Quality Commission (2019)	
Communication (8)			Care Commission, Mental Welfare Commissoion for Scotland (2009), Care Inspectorate (2012), Care Quality Commission (2019), Commission for Social Care Inspection (2006), National Institute for Health and Care Excellence (2014, 2015), The Health Foundation (2011)	Care Inspectorate (2020), Marshall (2018)
Delivery of care (12)	Szczepura et al. (2011)	Akhtar et al. (2015), Lim et al. (2016), Swift (2018), Sach et al. (2015) Patel and Donyai (2013)	Care Commission, Mental Welfare Commissoion for Scotland (2009), Care Quality Commission (2019), Care Inspectorate (2012), National Care Forum, (, 2013a), National Institute for Health and Care Excellence (2014, 2015), The Health Foundation (2011)	
Design (2)		Alldred et al. (2008)	The AHSN Network (2020)	
Form and packaging (3)	Gilmartin-Thomas et al. (2017), Alldred et al. (2011), Alldred et al. (2008)			
Incident rate (9)	Gilmartin-Thomas et al. (2017), Al-Hamadania et al. (2016), Santos Serrano et al. (2016), Szczepura et al., 2011 Barber et al. (2009), Alldred et al., 2008			Care Inspectorate (2020), Cheng et al. (2019), Marshall (2018)
Person centered (11)	Santos Serrano et al. (2016)	Lim et al. (2016), Gunnell et al. (2020)	Care Commission, Mental Welfare Commissoion for Scotland (2009), Care Inspectorate (2012), Care Quality Commission (2019), National Care Forum, (, 2013a), National Institute for Health and Care Excellence (2014, 2015), Smithard et al. (2019), Szczepura et al. (2008), The Health Foundation (2011), The Patients Association (2018), Wright et al. (2018)	
Records (5)		Alldred et al. (2008, 2011), Gunnell et al. (2020), Lim et al. (2016), Sach et al. (2015)		
Staffing (4)		Gunnell et al. (2020), Rivers et al. (2014)	The Health Foundation (2011)	Care Inspectorate (2020)
Staff development (10)		Alldred et al. (2008), Gunnell et al. (2020), Wild et al. (2011)	Care Quality Commission (2019), Commission for Social Care Inspection (2006), Szczepura et al. (2008), The AHSN Network (2020), The Health Foundation (2011)	Care Inspectorate (2020), Cheng et al. (2019)
Transfer of Care (8)		Gunnell et al. (2020), Alldred et al. (2015)	Care Quality Commission (2019), Joseph Rowntree Foundation (2008), National Institute for Health and Care Excellence (2014, 2015), Szczepura et al. (2008), The Health Foundation (2011)	Lang et al. (2017)

Donyai, 2013; Rivers et al., 2014; Sach et al., 2015; Swift, 2018; Wild et al., 2011). Further 11 documents made recommendations to reduce the rate of medicines-related incidents (Care Commission, Mental Welfare Commissoion for Scotland, 2009; Care Inspectorate, 2012; Care Quality Commission, 2019; Commission for Social Care Inspection, 2006; Joseph Rowntree Foundation, 2008; National Care Forum, (, 2013a); National Institute for Health and Care Excellence, 2014, 2015; The AHSN Network, 2020; The Health Foundation, 2011; The Patients Association, 2018; Smithard et al., 2019; Szczepura et al., 2008; Wright et al., 2018). Whilst four documents described implementing one or more changes and evaluated the impact of the change (Care Inspectorate, 2020; Cheng et al., 2019; Lang et al., 2017; Marshall, 2018).

Further coding categorized mechanisms as commissioning, delivery of care, design, form and packaging, incident rate, person centered, records, staffing and staff development. The characterization of the documents and themes are summarized within the fishbone diagram in Figure 2 and Table 3.

Rates and causes

Seven studies reported either an average medicine error rate or how the medicine error rate was influenced by a possible cause (Al-Hamadania et al., 2016; Alldred et al., 2008, 2011; Barber et al., 2009; Gilmartin-Thomas et al., 2017; Santos Serrano et al., 2016; Szczepura et al., 2011).

Six studies reported an average medicine error rate (Al-Hamadania et al., 2016; Alldred et al., 2008; Barber et al., 2009; Gilmartin-Thomas et al., 2017; Santos Serrano et al., 2016; Szczepura et al., 2011). Mean medicine error rates were generally described per administered dose, ranging from one study reporting 1.2% Szczepura et al. (2011), four between 7% and 9% (Al-Hamadania et al., 2016; Alldred et al., 2008; Barber et al., 2009; Gilmartin-Thomas et al., 2017) and a further study reporting 36.7% Santos Serrano et al. (2016).

Three studies (Alldred et al., 2008, 2011; Gilmartin-Thomas et al., 2017) across two population groups reported the impact of medicine formulations and packaging. These papers compared all medicines dispensed in their original packs (6.9%, 8.1% and 13.2%) to regularly administered tablets and capsules dispensed into multicompartment aids (3.1% and 4.2%) on average medicine error rates (Alldred et al., 2008, 2011; Gilmartin-Thomas et al., 2017). Two papers explored medicine error rates associated with non-tablet and capsule formulations including liquids (12.3%), inhalers (50.0%) and other routes including creams, patches, and injections (39.3%) (Alldred et al., 2008, 2011).

The effect of dysphasia on medicine error rates was explored in a further paper (Santos Serrano et al., 2016). This paper reported average medicine errors per administered doses of 29.7% for people not living with dysphasia and 59.2% for people living with dysphasia.

Cause

Eleven studies explored the causes of medicines errors (Akhtar et al., 2015; Alldred et al., 2015, 2008, 2010; Gunnell et al., 2020; Lim et al., 2016; Patel & Donyai, 2013; Rivers et al., 2014; Sach et al., 2015; Swift, 2018; Wild et al., 2011).

Delivery of care and its impact on medicine errors was explored within five papers (Akhtar et al., 2015; Gunnell et al., 2020; Lim et al., 2016; Patel & Donyai, 2013; Swift, 2018). Two studies described how care homes were supported to develop their policies and procedure, one study described the input provided by the pharmacy team within a clinical commissioning group (Swift, 2018), whilst the other reports focussed on the services delivered by community pharmacies to support care homes (Patel & Donyai, 2013). Possible improvements to the delivery of care were explored in two papers. One mapped medicines processes and recommended improvement for example improving access to records (Lim et al., 2016). The other paper described how templates for "when required medicines protocols" Akhtar et al. (2015) were improved through a quality improvement program to report on service improvement programs (Swift, 2018). The association between the CQC rating of inadequate and weaknesses with services medicines processes were described by Gunnell et al. (2020).

Five papers (Alldred et al., 2008, 2010; Gunnell et al., 2020; Lim et al., 2016; Sach et al., 2015) considered consistency of a persons' care and medical records held within and between services particularly local GPs. Two papers explored the consistecy of a person's records. Forty-eight medicine sensitivities were recorded across the records of 121 people living in care homes by Alldred et al. (2010). However, three sensitivities were recorded on the MAR, 29 in the care records and 35 within the GP records (Alldred et al., 2010). Sach et al. (2015) identified the consistency between GP and care home records GP appeared to be influenced by a number of factors including the number of prescribed medicines. The association between the CQC rating of inadequate and weaknesses with resident care records were described by Gunnell et al. (2020).

The benefits and need for staff training and development were explored in three papers (Alldred et al., 2008; Gunnell et al., 2020; Wild et al., 2011). Gunnell et al. (2020) described the association between the CQC rating of inadequate and a lack of staff development. Incidents such as staff interrupting colleagues administering medicines and poor administration technique were used by Alldred et al. (2008) to suggest that care staff would benefit from

Table 4. Summary of the CASP analysis of the identified documents.

	Study Validity								Results			Relevance		
Year & Author	1	2	3	4	5a	5b	6a	6b	1	2	3	1	2	3
Quantitative (Cohort)														
Care Inspectorate (2020)	Y	Y	Y	Y	P	P	Y	Y	-	-	Y	Y	Y	Y
Cheng et al. (2019)	Y	P	Y	Y	N	N	Y	Y	-	-	Y	Y	Y	Y
Marshall (2018)	Y	P	Y	Y	P	P	Y	Y	-	-	Y	Y	Y	Y
Swift (2018)	Y	N	N	N	P	P	N	N	-	-	Y	Y	Y	Y
Gilmartin-Thomas et al. (2017)	Y	Y	Y	Y	Y	Y	Y	Y	-	-	Y	Y	Y	Y
Lang et al. (2017)	Y	N	N	Y	Y	N	Y	Y	-	-	Y	Y	Y	Y
Al-Hamadania et al. (2016)	Y	P	Y	Y	N	N	Y	Y	-	-	P	Y	Y	Y
Santos Serrano et al. (2016)	Y	Y	Y	Y	P	P	Y	Y	-	-	Y	Y	N	Y
Alldred et al. (2015)	Y	N	P	P	P	P	P	Y	-	-	Y	Y	Y	Y
Sach et al. (2015)	Y	Y	Y	Y	N	N	Y	Y	-	-	Y	Y	P	Y
Rivers et al. (2014)	Y	Y	Y	P	Y	P	Y	Y	-	-	Y	Y	Y	Y
Patel and Donyai (2013)	Y	N	P	P	P	Y	P	Y	-	-	Y	Y	Y	Y
Alldred et al. (2011)	Y	Y	Y	Y	P	P	Y	Y	-	-	Y	Y	Y	Y
Szczepura et al. (2011)	Y	Y	P	Y	P	N	Y	Y	-	-	Y	Y	N	Y
Wild et al. (2011)	Y	Y	Y	N	P	N	Y	Y	-	-	Y	Y	Y	Y
Alldred et al. (2010)	Y	Y	Y	Y	Y	Y	Y	Y	-	-	Y	Y	Y	Y
Barber et al. (2009)	Y	Y	Y	Y	P	P	Y	Y	-	-	Y	Y	Y	Y
Alldred et al. (2008)	Y	Y	Y	Y	P	P	Y	Y	-	-	Y	Y	Y	Y
Qualitative														
Lim et al. (2016)	Y	Y	Y	Y	Y	-	Y	-	Y	P	Y	Y	-	-
Akhtar et al. (2015)	Y	Y	Y	P	Y	-	P	-	P	P	Y	Y	-	-
Review														
The AHSN Network (2020)	Y	Y	Y	Y	Y	-	-	-	-	-	-	Y	P	P
Gunnell et al. (2020)	Y	Y	Y	Y	Y	-	-	-	-	-	-	Y	Y	Y
Care Quality Commission (2019)	Y	Y	Y	Y	Y	-	-	-	-	-	-	Y	P	P
Smithard et al. (2019); The Patients Association (2018); Wright et al. (2018)	Y	P	P	P	P	-	-	-	-	-	-	Y	P	P
National Institute for Health and Care Excellence (2014, 2015)	Y	Y	Y	Y	Y	-	-	-	-	-	-	Y	Y	Y
National Care Forum, ((2013a))	Y	Y	Y	Y	Y	-	-	-	-	-	-	Y	Y	P
Care Inspectorate (2012)	Y	Y	P	Y	Y	-	-	-	-	-	-	Y	Y	Y
The Health Foundation (2011)	Y	Y	Y	Y	Y	-	-	-	-	-	-	Y	Y	P
Care Commission, Mental Welfare Commission for Scotland (2009)	Y	Y	Y	Y	Y	-	-	-	-	-	-	Y	Y	P
Joseph Rowntree Foundation, 2008	Y	P	P	P	P	-	-	-	-	-	-	Y	N	P
Szczepura et al. (2008)	Y	P	P	P	Y	-	-	-	-	-	-	Y	Y	P
Commission for Social Care Inspection (2006)	Y	Y	Y	Y	Y	-	-	-	-	-	-	Y	P	P

Key: (Y) Fulfills question, (P) partly answers question, (N) does answer question, (-) no direct question

additional training and development. Whilst Wild et al. (2011) described how staff development supported the roll out of a bar code medicine administration system.

Two papers explored person-centered care (Gunnell et al., 2020; Lim et al., 2016). One paper highlighted the need for the resident to be involved in decision-making (Lim et al., 2016). The other paper highlighted CQC enforcement action frequently resulted from the services lacking adequate resident-specific medicine risk assessments (Gunnell et al., 2020).

Staffing was explored by two papers (Gunnell et al., 2020; Rivers et al., 2014). One paper highlighted CQC enforcement action often resulted from the services having staffing issues particularity at medicine administration times

(Gunnell et al., 2020). Staff confidence in administering medicines and stress levels whilst administering medicines were explored in further paper (Rivers et al., 2014).

Transfer of care from hospitals to care homes was explored in two papers (Alldred et al., 2015; Gunnell et al., 2020). Care home manager views on hospital discharge processes from a postal survey were summarized in one paper (Alldred et al., 2015). The other paper highlighted CQC enforcement action resulted from care home staff not aware of all the medical changes for hospital admissions (Gunnell et al., 2020).

One study mapped the medicine supply and administration processes in care homes and where the care homes worked with other services (Lim et al., 2016). Based on the process mapping diagram, improvements to the equipment and building design were proposed (Lim et al., 2016).

Recommendations

Eleven documents were identified (Care Inspectorate, 2012; Care Commission, Mental Welfare Commissoion for Scotland, 2009; Care Quality Commission, 2019; Commission for Social Care Inspection, 2006; Joseph Rowntree Foundation, 2008; National Care Forum, , 2013a; National Institute for Health and Care Excellence, 2014, 2015; The AHSN Network, 2020; Smithard et al., 2019; Szczepura et al., 2008; The Health Foundation, 2011; The Patients Association, 2018; Wright et al., 2018) which made specific recommendations. Six documents were published by UK arm's length government bodies (Care Commission, Mental Welfare Commissoion for Scotland, 2009; Care Inspectorate, 2012; Care Quality Commission, 2019; Commission for Social Care Inspection, 2006; National Institute for Health and Care Excellence, 2014, 2015). Three reports were published by think tanks, and trade groups (Joseph Rowntree Foundation, 2008; National Care Forum, 2013a; The Health Foundation, 2011), two were supported by published literature reviews (National Care Forum, , 2013a, Szczepura et al., 2008) A charter was also published by a patient group specifically describing best practice for swallowing and medicines (Smithard et al., 2019; The Patients Association, 2018; Wright et al., 2018).

Improvements to person-centered care were recommended in eight documents (Care Commission, Mental Welfare Commissoion for Scotland, 2009; National Care Forum, 2013a; National Institute for Health and Care Excellence, 2014, 2015; Smithard et al., 2019; The Health Foundation, 2011; The Patients Association, 2018; Wright et al., 2018). Areas for improvement included ensuring legal and best practice guidance were followed prior to administering medicines covertly (Care Commission, Mental Welfare Commissoion for Scotland, 2009; Care Quality Commission, 2019; National Institute for Health and Care Excellence, 2014, 2015), which may

require independent advocates (The Health Foundation, 2011). Where residents have capacity, self-administration of medicines should be encouraged where appropriate (National Institute for Health and Care Excellence, 2014, 2015). Care planning should be person-centered (Care Commission, Mental Welfare Commissoion for Scotland, 2009; Care Inspectorate, 2012; Care Quality Commission, 2019; National Institute for Health and Care Excellence, 2014, 2015; The Health Foundation, 2011). Two charters were published, one concerning residents and their medicines (National Care Forum, 2013a, National Care Forum, 2013b) the other concerning residents, their medicines, and swallowing difficulties (Smithard et al., 2019; The Patients Association, 2018; Wright et al., 2018).

Six documents explored communication (Care Commission, Mental Welfare Commissoion for Scotland, 2009; Care Inspectorate, 2012; Care Quality Commission, 2019; Commission for Social Care Inspection, 2006; National Institute for Health and Care Excellence, 2014, 2015; The Health Foundation, 2011). Of these, four documents highlighted scope for improvement due to incomplete, duplicate, or inaccurate care home records (Care Commission, Mental Welfare Commissoion for Scotland, 2009; Care Inspectorate, 2012; Care Quality Commission, 2019; Commission for Social Care Inspection, 2006), and one recommended improvement in the information provided by prescribers to care homes about the prescribed medicines (National Institute for Health and Care Excellence, 2014, 2015). Communication between care home staff on a daily basis was also highlighted as an area for improvement (The Health Foundation, 2011).

Six documents explored delivery of care, four reports from UK arm's length government bodies (Care Commission, Mental Welfare Commissoion for Scotland, 2009; Care Inspectorate, 2012; Care Quality Commission, 2019; Commission for Social Care Inspection, 2006) and two documents from thinktanks and trade groups (National Care Forum, , 2013a, The Health Foundation, 2011). Recommendations to improve the delivery of care included improvements to medicines administration (Care Commission, Mental Welfare Commissoion for Scotland, 2009; Care Inspectorate, 2012; Care Quality Commission, 2019; Commission for Social Care Inspection, 2006; The Health Foundation, 2011), medicines security, and systems to support residents should they become unwell (National Care Forum, , 2013a). Recommended improvements to medicines administration included aligning the medicine administration times around critical and time-sensitive medicines (Care Inspectorate, 2012; The Health Foundation, 2011), investigating and reducing missed doses (Care Quality Commission, 2019). Improving medicine security related to preventing medicine trolleys being left open and unattended and the ensuring the safe storage of prescribed thickeners for drinks and liquid medicines (Care Quality Commission, 2019). Increased support for residents who became unwell included processes to safely

administer homely remedies for the treatment of self-limiting conditions and the identification, management, and escalation of a deteriorating resident (National Care Forum, , 2013a).

Gaps in staff development were highlighted in five documents (Care Quality Commission, 2019; Commission for Social Care Inspection, 2006; Szczepura et al., 2008; The AHSN Network, 2020; The Health Foundation, 2011). Two of the documents highlighted the specific areas for staff development. These concerned change management (Szczepura et al., 2008) and quality improvement and safety cultures (The AHSN Network, 2020).

Recommendations about of transfer of care were made in five documents (Care Quality Commission, 2019; Joseph Rowntree Foundation, 2008; National Institute for Health and Care Excellence, 2014, 2015; Szczepura et al., 2008; The Health Foundation, 2011). Three documents raised concerns about the completeness of information shared between organizations when people's care was transferred (Care Quality Commission, 2019; National Institute for Health and Care Excellence, 2014, 2015; The Health Foundation, 2011). Further two papers highlighted research was available about transfer of care from hospital to care homes; research was lacking concerning transfer of care between care homes (Joseph Rowntree Foundation, 2008; Szczepura et al., 2008).

CQC recommended that commissioner contracts should be clear about the oversight of medicines (Care Quality Commission, 2019). Digitalization of care home was recommended by the Academic Health Science Networks (The AHSN Network, 2020). Whilst the Health Foundation highlighted the need for adequate staffing levels (The Health Foundation, 2011).

Evaluation of change

Four papers (Care Inspectorate, 2020; Cheng et al., 2019; Lang et al., 2017; Marshall, 2018) described the implementation of a change of practice and the impact the change had on the reported medicine error rate. Three papers expressed the median medicine error rate per resident (Care Inspectorate, 2020; Cheng et al., 2019; Marshall, 2018), whilst a fourth expressed the mean medicine intervention rate per resident and per medicine (Lang et al., 2017). Improving communication were described in two papers (Care Inspectorate, 2020; Marshall, 2018). Both papers reported the benefits of removing discontinued and duplicate medicines from the medicine administration records. One paper also reported the benefits of a daily communication sheet, improving "when required" protocols within care plans and twice daily checks of the topical medicine administration records (Care Inspectorate, 2020). All of these changes led to a reduction in the number of reported incidents involving medicines reported in the paper by means of graphs.

Two papers described how staff development impacted on medicine-related incidents (Care Inspectorate, 2020; Cheng et al., 2019). One paper reported that staff development reduced medicines incident rates (Care Inspectorate, 2020). Whilst the other paper reported that the number of potential incidents involving medicines prevented by an electronic medicines administration system were not significantly different between care workers who had received additional training and nursing staff (Cheng et al., 2019).

The use of regular agency staff was reported by one paper to reduce the number of medicine-related incidents (Care Inspectorate, 2020). Whilst another paper demonstrated the frequency of pharmacist interventions made by a step-down clinic following the discharge of hospital patients back to their care home that many not have been identified had the resident not attended the clinic (Lang et al., 2017).

Critical appraisal of the evidence

Three CASP checklists (Critical Appraisal Skills Programme, , 2018) were used to assess the quality of the included documents. these were for cohort and qualitative studies and systematic reviews. The questions asked within the checklists were answered: yes, partial or no. The checklist answers have been summarized in Table 4.

All the identified papers addressed a clearly focussed issue, and the results could be applied to the local population. Further four documents, two using the cohort and two using the review checklists, were assessed as containing sufficient relevant information that all the CASP checklist questions were answered as "yes" (Alldred et al., 2010; Gilmartin-Thomas et al., 2017; Gunnell et al., 2020; National Institute for Health and Care Excellence, 2014, 2015). Seventeen documents, six using the cohort checklist, two using the qualitative checklist and nine using the review checklist were assessed as either "partial" or "yes" for containing sufficient relevant information for all the CASP checklist questions (Akhtar et al., 2015; Alldred et al., 2008, 2011; Barber et al., 2009; Care Commission, Mental Welfare Commissoion for Scotland, 2009; Care Inspectorate, 2012, 2020; Care Quality Commission, 2019; Commission for Social Care Inspection, 2006; Lim et al., 2016; Marshall, 2018; National Care Forum, 2013; Rivers et al., 2014; Smithard et al., 2019; Szczepura et al., 2008; The AHSN Network, 2020; The Health Foundation, 2011; The Patients Association, 2018; Wright et al., 2018). The remaining 11 documents were assessed as lacking sufficient relevant information requiring a "no" answer to one or more questions (Al-Hamadania et al., 2016; Alldred et al., 2015; Cheng et al., 2019; Joseph Rowntree Foundation, 2008; Lang et al., 2017; Patel & Donyai, 2013; Sach et al., 2015; Santos Serrano et al., 2016; Swift, 2018; Szczepura et al., 2011; Wild et al., 2011).

Limitations identified by the cohort CASP analysis tool resulting in documents being classified as "partial" were associated with questions concerning the identification and minimization of confounding factors such as assuming the accuracy of the MAR and descriptions of service development programs within the cohort studies (Alldred et al., 2015, 2008, 2011; Barber et al., 2009; Care Inspectorate, 2020; Marshall, 2018; Santos Serrano et al., 2016; Swift, 2018). The qualitative CASP analysis tool identified that most documents were classified a "partial" for the question concerning whether the data analysis was sufficiently rigorous (Akhtar et al., 2015; Lim et al., 2016). The application of the CASP systematic analysis tool to documents making recommendations highlighted that nine of the 12 documents only partially considered "are the benefits worth the harms and costs?" (Care Commission, Mental Welfare Commissoion for Scotland, 2009; Care Quality Commission, 2019; Commission for Social Care Inspection, 2006; Joseph Rowntree Foundation, 2008; National Care Forum, , 2013a; Smithard et al., 2019; Szczepura et al., 2008; The AHSN Network, 2020; The Health Foundation, 2011; The Patients Association, 2018; Wright et al., 2018).

Limitations identified by the cohort CASP analysis tool sufficient to result in an "no" response to a question were associated with the minimization of confounding factors within the cohort studies (Al-Hamadania et al., 2016; Cheng et al., 2019; Lang et al., 2017; Sach et al., 2015; Szczepura et al., 2011; Wild et al., 2011), cohort recruitment (Alldred et al., 2015; Lang et al., 2017; Patel & Donyai, 2013; Swift, 2018) and the study results fit with other evidence (Santos Serrano et al., 2016; Szczepura et al., 2011).

Discussion

The average medicines incident rates reported in 2008 by Alldred et al. (2008) and 2009 by Barber et al. (2009) was 8.4% per administered dose. A later study conducted by Gilmartin-Thomas et al. (2017) showed a reduction (7.1%). Szczepura et al. (2011) reported a 1.2% of averted administration errors and in 2016 Al-Hamadania et al. (2016) reported 8% from a retrospective record analysis. Santos Serrano et al. in 2016 reported 36.7%, whilst investigating the impact of dysphagia. Due to differences in study design, these five medicine incident rates were difficult to compare. However, they demonstrated the wide range in reported results.

The impact of the presentation of the medicines was examined as a subgroup analysis Alldred et al. (2011) of a larger study Alldred et al. (2008) and through a double-armed observational study Gilmartin-Thomas et al. (2017). Both studies concluded that the use of MCAs compared to medicines in their original packs reduced the observed medicine incident rate within care homes. However, not all medicines can be supplied via MCAs, for example, liquids, patches, inhalers, and

eye drops. Therefore, services using MCAs for tablets and capsules must administer other medicines from original packs. The analysis of the results published by Gilmartin-Thomas et al. (2017) showed an increase in the medicine error rate from 8.1% when administering only from original packs to 13.2% when administering medicines from original packs when the services had original packs as well as MCAs for regular tablets and capsules. The cause of this difference was unclear but contributing factors could be dual systems or a higher medicine incident rate attributable to liquid (12.2%), inhaler (50%) and others (39.3%) non-tablet original pack medicines as reported by Alldred et al. (2011).

The regulators (Alldred et al., 2010; Care Quality Commission, 2019; Commission for Social Care Inspection, 2006) reported poor consistency of allergy information between the records. The regulators looked at the different records within the care home, while Alldred *et al*. compared care home records to those of the GP.

Patel and Donyai (2013) concluded that whilst advice on medicine waste and policies was provided to care homes, advice on medicine errors, adverse drug reactions and audit were not provided. Another survey Alldred et al. (2015) identified that whilst the majority of care homes use MCAs and MARs, systems were not in place to re-introduce them on discharge from hospital.

A consistent limitation of these papers and regulators' reports describing medicine-related incidents rates was the assumption that the MAR accurately reflected the medicines administered to the resident. For example, omitted doses, due to the non-availability of the MAR and the medicine would not have been identified as a medicine-related incident. Therefore, the reported rates of medicine incidents were potentially underestimated.

Three studies (Alldred et al., 2008; Lim et al., 2016; Patel & Donyai, 2013), four service development programs (Care Inspectorate, 2020; Cheng et al., 2019; Lang et al., 2017; Marshall, 2018) and 11 gray documents (Care Commission, Mental Welfare Commissoion for Scotland, 2009; Care Inspectorate, 2012; Care Quality Commission, 2019; Commission for Social Care Inspection, 2006, Joseph Rowntree Foundation, 2008; National Care Forum, 2013; National Institute for Health and Care Excellence, 2014, 2015; Smithard et al., 2019; Szczepura et al., 2008; The AHSN Network, 2020; The Health Foundation, 2011; The Patients Association, 2018; Wright et al., 2018) described how different aspects of medicine optimization could be improved. However, only the four service development programs implemented a change and assessed the outcome (Care Inspectorate, 2020; Cheng et al., 2019; Lang et al., 2017; Marshall, 2018). In 2019, an observational study showed no significant differences between the number of potential medicine-related incidents stopped by an e-MAR made by care workers and nurses (Cheng et al., 2019). One study (Lang et al., 2017) quantified the interventions undertaken by pharmacists supporting complex discharges to care homes, an average of 2.8

medicine interventions per patient transfer demonstrated a reduction in potential harm to the person. A service development paper in 2018 demonstrated duplicate entries and discontinued medicines remaining on MAR charts contributed reduction in reported medicine error rates (Marshall, 2018). This paper described using quality improvement methodology, identified, and implemented single changes within the service and the impact of the change was monitored through the ongoing reporting and recording of the rate of incidents involving medicines. A further paper (Care Inspectorate, 2020) published in 2020 demonstrated how the learning from the earlier study by Marshall (2018) could be scaled up across 10 care homes. The later papers showed that a reduction in the recording of incidents involving medicines could be achieved across more than one service through the application of a general quality improvement program and service-specific changes to practice.

Critical appraisal of the evidence

Critical appraisal of the evidence using the CASP checklists provided a framework to assess the resilience of gray literature to academic review, through the application of an evidence-based checklist across all the identified papers (Table 4). The checklist highlighted that all the papers addressed a clearly focussed issue, and the results could be applied to the local population. An area of weakness across the documents concerned the potential for bias through the identification of participant groups. Whilst a weakness of these studies, this should not be unexpected as the conversion rate for approached care homes to participate in research was calculated by Ellwood *et al*. as 5.3%, even with a targeted approach via "research-ready care homes" (Ellwood et al., 2018). A further weakness identified through the CASP analysis was "are the benefits worth the harms and costs?" associated with papers making recommendations, largely due to the anticipated reduction in harm, not being quantified in severity or monetary terms, nor the investment required to deliver the reduction in harm.

Implications for policy and research

These findings highlight the UK-specific published evidence relating to medicines-related incident rates, identified causes of medicine incidents in care homes and the variation in published incident rates. There was a lack of published research or service development programs describing how changes identified in the papers proposed in the identified papers to medicine trolleys and other equipment, use of technology, and or operational processes affect the incidence of harm from medicine-related incidents to people living in care homes. Furthermore, the lack of a standardized tool for assessing or comparing one process with another within the care homes setting was identified.

Strengths and limitations

To the best of our knowledge, this is the first scoping review focussing on medicine incident rates in UK care homes. The major limitation of this research is the limited number of studies included. Also, the gray literature search identified that most clinical commissioning groups have their own audit tools. However, they were excluded, as not all were publicly available. The literature search also excluded non-UK studies, even if these could have been relevant and informed our findings.

Conclusion

This scoping review highlighted several findings. The first was that different average medicine incident rates per administered dose were described in the published literature, ranging between 1.2% and 38%, with three studies describing a rate of around 8%. The second was that medicine incident rates increased with formulations that were not tablets or capsules within a range of 12% to 50% depending on the formulation. Due to differences in the study designs, the average medicine incident rate was not calculated across the studies. The third result was informed by three studies evaluating the effectiveness of different inventions to reduce the rate of incidents involving medicines. Two evaluated improvements to the care home records and improved communication within care homes, the other introduced medicine review for people with complex medicines discharged from hospitals to care homes. The results suggest the need to conduct further studies to clarify and improve our understanding of medicine incident rates in care homes. Finally, the results of this review highlight the need to develop, test, validate, and standardize a more robust approach and tool for assessing the effectiveness of systems and processes to minimize harm from medicines in care homes in the UK.

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Appendix A. Search strategies executed in EMBASE – on-line if shown

Search	Search terms (using Boolean operators OR, AND)	Number of results
1	(medication? OR "drug? Therapy" OR "drug? Administration" OR "drug? Therapy" OR "drug or medicinal products" OR prescribing). Abstract (ab), Key words (kw), Title (ti) fields	719,418
2	(("care home" OR "nursing home" OR "residential home" OR "home care" OR "residential care" OR "residential services" OR "residential facilities") ab,kw,ti	58,240
3	(error? Or incident? Or safety or accident? Or "medication? Error?"). ab,kw,ti.	144,220
4	(1 AND 2 AND 3)	932
5	(1 AND 2 AND 3) [Human]	874
6	(1 AND 2 AND 3) [Human] [DT FROM 2006]	788
7	(audit OR learning OR improvement OR evaluation OR "quality of healthcare" OR "quality of social care" OR "health care quality" OR "clinical audit" OR "medical audit" OR "quality assurance") ab,kw,ti	3,026,910
8	(1 and 2 and 8)	1260
9	(1 AND 2 AND 8) [Human]	1177
10	(1 AND 2 AND 8) [Human] [DT FROM 2006]	992