

Applied Clinical Informatics

Interventions to mitigate EHR and documentation burden in health professions trainees: A scoping review

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Abstract:

Background: Health professions trainees (trainees) are unique as they learn a chosen field while working within electronic health records (EHR). Efforts to mitigate EHR burden have been described for the experienced health professional (HP), but less is understood for trainees. EHR or documentation burden (EHR burden) affects trainees, although not all trainees use EHRs, and use may differ for experienced HPs.

Objectives: To develop a model of how interventions to mitigate EHR burden fit within the trainee EHR workflow: the Trainee EHR Burden Model. 1) Examine trainee experiences of interventions aimed at mitigating EHR burden (scoping review). 2) Adapt an existing workflow model by mapping included studies (concept clarification).

Methods: We conducted a 4-database scoping review applying PRISMA-ScR guidance, examining scholarly, peer-reviewed studies that measured trainee experience of interventions to mitigate EHR burden. We conducted a concept clarification categorizing, then mapping studies to workflow model elements. We adapted the model to intervenable points for trainee EHR burden.

Results: We identified 11 studies examining interventions to mitigate EHR burden that measured trainee experience. Interventions included: curriculum, training, coaching on the existing EHR for both simulated or live tasks; evaluating scribes' impact; adding devices or technology tailored to rounds; team communication or data presentation at end-of shift handoffs. Interventions had varying effects on EHR burden, most commonly measured through surveys, and less commonly, direct observation. Most studies had limited sample sizes, focused on inpatient settings, and physician trainees.

Conclusion: Few studies measured trainee perspectives of interventions aiming to mitigate EHR burden. Many studies applied quasi-experimental designs and focused on inpatient settings. The Trainee EHR Burden Model, adapted from an existing workflow model, offers a starting place to situate points of intervention in trainee workflow. Further research is needed to design new interventions targeting stages of HP trainee workflow, in a range of clinical settings.

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Table 1:

Table 1: Search Strategies* for Scoping Review (*Conducted 11/28-12/25/2023)	
Ovid Medline (292)	
1	exp Medical Records Systems, Computerized/ (49084)
2	exp education, professional/ (333407)
3	exp schools, health occupations/ (46555)
4	exp Students, Health Occupations/ (88977)
5	2 or 3 or 4 (392275)
6	exp Stress, Psychological/ (154333)
7	exp emotions/ (417784)
8	exp attitude of health personnel/ (170478)
9	exp Personnel Staffing/ and Scheduling/ (18087)
10	exp workflow/ (9212)
11	6 or 7 or 8 or 9 or 10 (719635)
12	1 and 5 and 11 (188)
13	((ehr or ehra or emr or emrs or cis or ((electronic* or computer*) adj3 (health* or medic* or patient* or patholog*) adj5 (record* or documentation*))) adj10 (teach* or train* or learn* or educat* or instruct* or interven*)).mp. [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms, population supplementary concept word, anatomy supplementary concept word] (8158)
14	5 and 13 (806)
15	((ehr or ehra or emr or emrs or cis or ((electronic* or computer*) adj3 (health* or medic* or patholog*) adj3 (record* or documentation*))) adj5 (teach* or train or trains or training or trained or learn* or educat* or instruct* or interven*) adj10 (student* or trainee* or resident or residents or residency or intern or interns or internship* or fellow*)).mp. [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms, population supplementary concept word, anatomy supplementary concept word] (239)
16	((ehr or ehra or emr or emrs or cis or ((electronic* or computer*) adj3 (health* or medic* or patholog*) adj3 (record* or documentation*))) adj5 (reorg* or restructur* or transform* or innovat* or chang* adj3 (manag* or launch* or institut* or inaugur* or begin* or initia* or implement* or enact* or accomplish* or perform* or execut*))) adj10 (student* or trainee* or resident or residents or residency or intern or interns or internship* or fellow*)).mp. [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms, population supplementary concept word, anatomy supplementary concept word] (6)
17	14 or 15 (915)
18	11 and 17 (108)
19	12 or 18 (214)
20	(burden* or anxi* or fear* or suffer* or burnout* or (burn* adj2 out) or ((psycholog* or emoti* or personal* or experienc* or develop* or work* or job* or occupation*) adj7 (stress* or distress* or discomfort* or load* or overload* or challeng* or weigh* or encumb* or toll* or damag* or harm* or danger* or risk* or hazard* or advers* or injur* or detriment*))).mp. [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms, population supplementary concept word, anatomy

supplementary concept word] (2015726)

21 1 and 5 (1373)

22 14 or 21 (1562)

23 20 and 22 (105)

24 ((ehr or ehrrs or emr or emrs or cis or ((electronic* or computer*) adj3 (health* or medic* or patient* or patholog*) adj5 (record* or documentation*))) adj7 (student* or trainee* or resident or residents or residency or intern or interns or internship* or fellow*) adj10 (burden* or anxi* or fear* or suffer* or burnout* or (burn* adj2 out) or ((psycholog* or emoti* or personal* or experienc* or develop* or work* or job* or occupation*) adj7 (stress* or distress* or discomfort* or load* or overload* or challeng* or weigh* or encumb* or toll* or damag* or harm* or danger* or risk* or hazard* or advers* or injur* or detriment*))).mp. [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms, population supplementary concept word, anatomy supplementary concept word] (23)

25 19 or 23 or 24 (292)

Cochrane Database of Systematic Reviews (5)

"Electronic health record" AND "trainee" AND "burden or stress" in Title
Abstract Keyword - (Word variations have been searched)

Embase (274)

((('electronic medical record system'/exp OR 'electronic health record'/exp) AND ('medical education'/exp OR 'paramedical education'/exp OR 'medical school'/exp OR 'health student'/exp) AND ('mental stress'/exp OR 'psychological resilience'/exp OR 'emotion'/exp OR 'health personnel attitude'/exp OR 'personnel management'/exp OR 'work'/exp OR 'workflow'/exp OR 'psychomotor performance'/exp)) OR (((('electronic* OR computer*') NEAR/3 (health* OR medic* OR patient* OR patholog*) AND (health* OR medic* OR patient* OR patholog*) NEAR/5 (record* OR documentation*)) AND (record* OR documentation*) NEAR/10 (teach* OR train* OR learn* OR educat* OR instruct* OR interven*)) AND ((reorg* OR restructur* OR transform* OR innovat*) NEAR/10 (student* OR trainee* OR resident OR residents OR residency OR intern OR interns OR internship* OR fellow*) OR (chang* NEAR/3 (manag* OR launch* OR institut* OR inaugur* OR begin* OR initia* OR implement* OR enact* OR accomplish* OR perform* OR execut*) AND (manag* OR launch* OR institut* OR inaugur* OR begin* OR initia* OR implement* OR enact* OR accomplish* OR perform* OR execut*) NEAR/10 (student* OR trainee* OR resident OR residents OR residency OR intern OR interns OR internship* OR fellow*))) OR (('mental stress'/exp OR 'psychological resilience'/exp OR 'emotion'/exp OR 'health personnel attitude'/exp OR 'personnel management'/exp OR 'work'/exp OR 'workflow'/exp OR 'psychomotor performance'/exp) AND (((('electronic* OR computer*') NEAR/3 (health* OR medic* OR patient* OR patholog*) AND (health* OR medic* OR patient* OR patholog*) NEAR/5 (record* OR documentation*)) AND (record* OR documentation*) NEAR/10 (teach* OR train* OR learn* OR educat* OR instruct* OR interven*)) AND (teach* OR train OR trains OR training OR trained OR learn* OR educat* OR instruct* OR interven*) NEAR/10 (student* OR trainee* OR resident OR residents OR residency OR intern OR interns OR internship* OR fellow*))) OR (((burden* OR anxi* OR fear* OR suffer* OR burnout* OR (burn* NEAR/2 out)) OR (psycholog* OR emoti* OR personal* OR experienc* OR develop* OR work* OR job* OR occupation*) NEAR/7 (stress* OR distress* OR discomfort* OR load* OR overload* OR challeng* OR weigh* OR encumb* OR toll* OR damag* OR harm* OR danger* OR risk* OR hazard* OR advers* OR injur* OR detriment*)) AND (('electronic medical record system'/exp OR 'electronic health record'/exp) AND ('medical education'/exp OR 'paramedical education'/exp OR 'medical school'/exp OR 'health student'/exp))) OR (((('electronic* OR computer*') NEAR/3 (health* OR medic* OR patient* OR patholog*) AND (health* OR medic* OR patient* OR patholog*) NEAR/5 (record* OR documentation*)) AND (record* OR documentation*) NEAR/10 (teach* OR train* OR learn* OR educat* OR instruct* OR interven*)) AND (teach* OR train OR trains OR training OR trained OR learn* OR educat* OR instruct* OR interven*) NEAR/10 (student* OR trainee* OR resident OR residents OR residency OR intern OR interns OR internship*

OR fellow*) AND ((burden* OR anxi* OR fear* OR suffer* OR burnout* OR (burn* NEAR/2 out)) OR (psycholog* OR emoti* OR personal* OR experienc* OR develop* OR work* OR job* OR occupation*) NEAR/7 (stress* OR distress* OR discomfort* OR load* OR overload* OR challeng* OR weigh* OR encumb* OR toll* OR damag* OR harm* OR danger* OR risk* OR hazard* OR advers* OR injur* OR detriment*))) AND [embase]/lim) NOT (((('electronic medical record system'/exp OR 'electronic health record'/exp) AND ('medical education'/exp OR 'paramedical education'/exp OR 'medical school'/exp OR 'health student'/exp) AND ('mental stress'/exp OR 'psychological resilience'/exp OR 'emotion'/exp OR 'health personnel attitude'/exp OR 'personnel management'/exp OR 'work'/exp OR 'workflow'/exp OR 'psychomotor performance'/exp)) OR (((electronic* OR computer*) NEAR/3 (health* OR medic* OR patient* OR patholog*) AND (health* OR medic* OR patient* OR patholog*) NEAR/5 (record* OR documentation*)) AND (record* OR documentation*) NEAR/10 (teach* OR train* OR learn* OR educat* OR instruct* OR interven*)) AND ((reorg* OR restructur* OR transform* OR innovat*) NEAR/10 (student* OR trainee* OR resident OR residents OR residency OR intern OR interns OR internship* OR fellow*) OR (chang* NEAR/3 (manag* OR launch* OR institut* OR inaugur* OR begin* OR initia* OR implement* OR enact* OR accomplish* OR perform* OR execut*) AND (manag* OR launch* OR institut* OR inaugur* OR begin* OR initia* OR implement* OR enact* OR accomplish* OR perform* OR execut*) NEAR/10 (student* OR trainee* OR resident OR residents OR residency OR intern OR interns OR internship* OR fellow*)))) OR (('mental stress'/exp OR 'psychological resilience'/exp OR 'emotion'/exp OR 'health personnel attitude'/exp OR 'personnel management'/exp OR 'work'/exp OR 'workflow'/exp OR 'psychomotor performance'/exp) AND (((electronic* OR computer*) NEAR/3 (health* OR medic* OR patient* OR patholog*) AND (health* OR medic* OR patient* OR patholog*) NEAR/5 (record* OR documentation*)) AND (record* OR documentation*) NEAR/10 (teach* OR train* OR learn* OR educat* OR instruct* OR interven*)) AND (teach* OR train OR trains OR training OR trained OR learn* OR educat* OR instruct* OR interven*) NEAR/10 (student* OR trainee* OR resident OR residents OR residency OR intern OR interns OR internship* OR fellow*)) OR (((burden* OR anxi* OR fear* OR suffer* OR burnout* OR (burn* NEAR/2 out)) OR (psycholog* OR emoti* OR personal* OR experienc* OR develop* OR work* OR job* OR occupation*) NEAR/7 (stress* OR distress* OR discomfort* OR load* OR overload* OR challeng* OR weigh* OR encumb* OR toll* OR damag* OR harm* OR danger* OR risk* OR hazard* OR advers* OR injur* OR detriment*)) AND (('electronic medical record system'/exp OR 'electronic health record'/exp) AND ('medical education'/exp OR 'paramedical education'/exp OR 'medical school'/exp OR 'health student'/exp))) OR (((electronic* OR computer*) NEAR/3 (health* OR medic* OR patient* OR patholog*) AND (health* OR medic* OR patient* OR patholog*) NEAR/5 (record* OR documentation*)) AND (record* OR documentation*) NEAR/10 (teach* OR train* OR learn* OR educat* OR instruct* OR interven*)) AND (teach* OR train OR trains OR training OR trained OR learn* OR educat* OR instruct* OR interven*) NEAR/10 (student* OR trainee* OR resident OR residents OR residency OR intern OR interns OR internship* OR fellow*)) AND ((burden* OR anxi* OR fear* OR suffer* OR burnout* OR (burn* NEAR/2 out)) OR (psycholog* OR emoti* OR personal* OR experienc* OR develop* OR work* OR job* OR occupation*) NEAR/7 (stress* OR distress* OR discomfort* OR load* OR overload* OR challeng* OR weigh* OR encumb* OR toll* OR damag* OR harm* OR danger* OR risk* OR hazard* OR advers* OR injur* OR detriment*)))) AND [medline]/lim) (274)

Web Of Science (249)

("electronic health record" AND "burden or stress" AND "trainee or student or resident") AND SHOULD INCLUDE "intervention or reduce or mitigate" (249)

Appendix 1. Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	5-6
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	6-7
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	Not registered, search strategy available on p7-9 of text, Appendix 1
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	8-9; Table 1 and Table 2
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	7-8; Table 1, Appendix 1

Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Appendix 1 (Extracted Citations, n = 11), Table 1 (Inclusion/Exclusion Criteria)
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	7-8; Table 1
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	8-9, including section 3.b Concept Clarification, Figure 1
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	8-9; Table 1, Table 2, Appendix 1
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	9-10, including 3.3 Concept Clarification
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	10-11 including concept clarification section
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	10-12, Figure 1 (PRISMA), Table 2, Table 3
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	11-14; Table 2, Table 3,
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	12-15; Table 3, Figure 2, Figure
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	12-15; Table 2, Table 3, Figure 2

Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	14-15; Table 3, Figure 2, Figure 3
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	15-16
Limitations	20	Discuss the limitations of the scoping review process.	16-18
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	18-20
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	24

JBİ = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBİ guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Ann Intern Med.* 2018;169:467–473. doi: 10.7326/M18-0850.

Appendix 3: Glossary of terms related to Trainees, Workflow, and Documentation burden

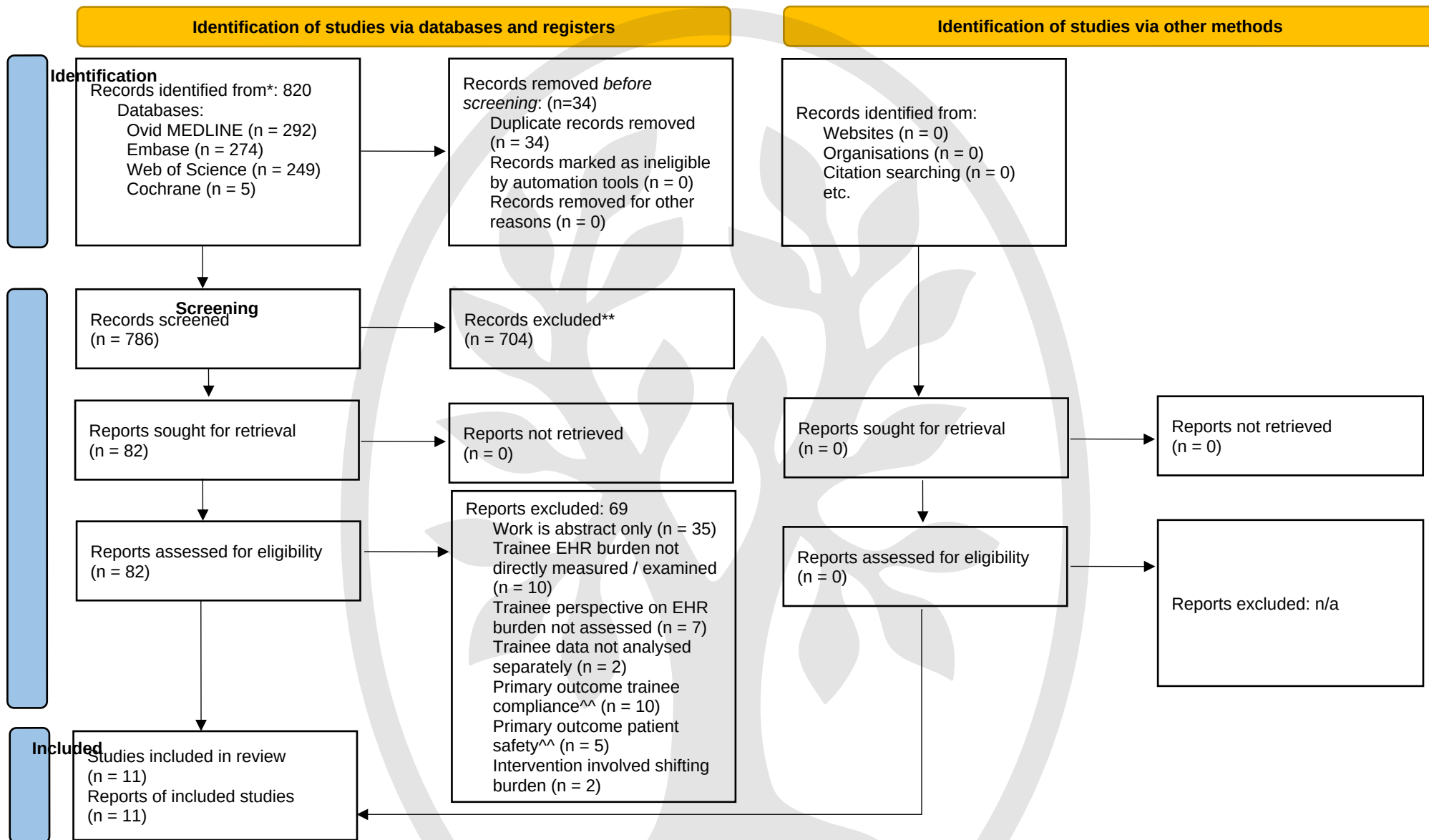
Group of definitions	Term	Definition
Trainees	Health Profession	<i>“Health professionals maintain health in humans through the application of the principles and procedures of evidence-based medicine and caring. Health professionals study, diagnose, treat and prevent human illness, injury and other physical and mental impairments in accordance with the needs of the population they service. They advise on or apply preventive and curative measures, and promote health with the ultimate goal of meeting the health needs and expectations of individuals and populations, and improving population health outcomes...”[1]</i>
	Health professions trainee	Health professions trainees are defined as individuals appointed to temporary positions in one or more [medial facilities] performing clinical experiences under supervision.[2]
EHR, Documentation and Documentation Burden	Electronic health record[3]	<i>“A repository of electronically maintained information about an individual’s lifetime health status and health care, stored such that it can serve the multiple legitimate users of the record.”[3]</i>
	Synthesis of patient data (into clinical impressions)[4]	The process by which a health professional reviews objective and subjective data regarding a patient case through application of clinical skills, in support of patient diagnosis and treatment.
	Burden[5]	<i>“Burden is defined as the load (e.g., cognitive load, workload, or task load) experienced by a [health professional] or healthcare team that is a necessary part of carrying out an activity or task required for care delivery (i.e.; medication administration, documenting a visit plan, writing a procedure or operative note).”[5], Table 5</i>
	Documentation[5]	<i>“Documentation is the patient-centered collection or generation of clinical data, review of clinical data, analysis of clinical data, and synthesis of clinical data, all in support of direct patient care needs. These documentation tasks include but are not limited to the inputs and outputs necessary to support all aspects of the care and communication with the patient (e.g., the authoring of notes or flowsheets, synthesizing clinical data into diagnoses or clinical impressions, creation of care or treatment plans, and communication through the EHR⁴¹ with patients and other HPs).”[5], Table 5</i>
	Documentation Burden[5]*	<i>“Expected load (see Documentation above) on [health professional] of completing necessary tasks included in the documentation and EHR interaction.”[5], Table 5</i>
	Communication through EHR[6]	Sharing and discussion of information between individuals (between different health professionals or between health professionals and patients) in support of patient care.
	Developing clinical impression(s)[7, 8]	This is a step in the medical decision-making process for a health professional (e.g., prescribing or ordering provider), and includes building on the synthesis of patient data, to support developing a list of potential diagnoses or conditions that might fit the current clinical scenario.

	Tasks[9, 10]	Health-related activities that are conducted by health professional resource users in their personal or professional lives.[9] This can include primary or secondary tasks which are performed.[10]
	Medication administration[11]	The steps included, typically in an inpatient healthcare setting, where a patient receives a pharmacologic treatment from a healthcare provider (e.g., nurse).
Workflow	Workflow	<i>“Workflow is the sequence of physical and mental tasks performed by the various people within and between work environments. It can occur at several levels (one person, between people, across organizations) and can occur sequentially or simultaneously.”</i> [12]
	Unertl Workflow Technology Model[13]	<i>“We [developed] a conceptual framework of elements to consider including when studying workflow regardless of field, the Workflow Elements Model (figure 3). The model has two levels: pervasive and specific.. Considering context is critical in workflow studies including the physical workspace, the virtual workspace and organizational factors.”</i> [13] <i>“The relationship among [model elements] and the importance of the various elements in the analysis of workflow depends on the researcher perspective, dependent variables, research questions and contextual factors. [The Workflow Elements Model provides] a flexible structure for consideration by researchers designing and reporting on workflow studies.”</i> [13]
	Workload[14, 15]	<i>“The attributes of workload in nursing have been defined in terms of the amount of time to complete a task, expertise of the person completing a task, amount of physical exertion, and task complexity. [The] terms cognitive workload and mental workload are synonymous in the literature.”</i> [14]
ANIA Framework 6 Domains of Burden[16]	Interoperability/Standards[16]	<i>“Insufficient configuration standards resulting in duplication and re-entry of data even though it resides elsewhere, either internal to the organization or in an external system.”</i>
	Quality[16]	<i>“Documentation required to demonstrate that quality patient care has been provided. This includes documentation requirements by the healthcare organization itself, as well as by governmental and regulatory agencies.”</i>
	Regulatory[16]	<i>“Accreditation agency documentation requirements.”</i>
	Reimbursement[16]	<i>“Documentation, coding and other administrative data entry tasks required for payment.”</i>
	Self-imposed[16]	Organization culture’s influence on what should be documented, when it exceeds what is needed for patient care, including due to fear of litigation; referring to “we’ve always done it this way”, inadequate education, and/or misinterpretation of regulatory standards. (adapted from [16])
	Usability[16]	<i>“Limited and insufficient use of human factors engineering and human computer interface principles resulting in extra time spent entering data, scrolling, clicking and searching for pertinent information in the [record or EHR].”</i>

Key: *For the purposes of this manuscript, EHR burden was used as synonymous with the documentation burden definition presented in reference [5].

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*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).

**No automation tools were used.

^^ Primary outcome noted, impact on EHR burden unclear

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: <http://www.prisma-statement.org/>

Figure 1. PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources

Interventions to mitigate EHR and documentation burden in health professions trainees: A scoping review

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Keywords: electronic health records and systems; documentation burden; EHR burden; clinician documentation; health informatics trainees; students.

After reading this work: Readers will understand the concept of EHR or documentation burden and be able to identify how a model of trainee EHR workflow can support interventions to mitigate trainee EHR burden.

Research Question: What interventions can be identified to mitigate EHR or documentation burden for health professions trainees (scoping review), and at what point in their daily or training workflow can these interventions be applied (concept clarification)?

ABSTRACT

Background: Health professions trainees (trainees) are unique as they learn a chosen field while working within an electronic health record (EHR). Efforts to mitigate EHR burden have been described for the experienced health professional (HP), but less is understood for trainees. EHR or documentation burden (*EHR burden*) affects trainees, although not all trainees use EHRs, and use may differ for experienced HPs.

Objectives: To develop a model of how interventions to mitigate EHR burden fit within the trainee EHR workflow, the *Trainee EHR Burden Model*. 1) Examine trainee experiences of interventions aimed at mitigating EHR burden (scoping review). 2) Adapt an existing workflow model by mapping included studies (concept clarification).

Methods: We conducted a 4-database scoping review, applying PRISMA-ScR guidance, examining scholarly, peer-reviewed studies that measured trainee experience of interventions to mitigate EHR burden. We conducted a concept clarification categorizing, then mapping studies to workflow model elements. We adapted the model to intervenable points for trainee EHR burden.

Results: We identified 11 studies examining interventions to mitigate EHR burden that measured trainee experience. Interventions included: curriculum, training, and coaching on the existing EHR for both simulated or live tasks; evaluating scribes' impact; adding devices or technology tailored to rounds; team communication or data presentation at end-of shift handoffs. Interventions had varying effects on EHR burden, most commonly measured through surveys, and less commonly, direct observation. Most studies had limited sample sizes, focused on inpatient settings, and physician trainees.

Conclusion: Few studies measured trainee perspectives of interventions aiming to mitigate EHR burden. Many studies applied quasi-experimental designs and focused on inpatient settings. The *Trainee EHR Burden Model*, adapted from an existing workflow model, offers a starting place to situate points of intervention in trainee workflow. Further research is needed to design new interventions targeting stages of HP trainee workflow, in a range of clinical settings.

1 BACKGROUND AND SIGNIFICANCE

Health professions trainees (henceforth *trainees*) are unique in that they are learning their field¹ and the electronic health record (EHR) simultaneously.² Trainees are reporting unprecedented levels of stress and burnout,^{3,4,5,6} to which EHR burden may contribute,⁷ with as yet unknown impacts on the future health of the trainee workforce.⁸ Rates of burnout were higher for surgical trainees than experienced surgeons in the same institution.⁹ The increased presence and usage of EHRs since 2011 has coincided with the increased discussion of impacts of EHRs on trainees.^{10,11,12,13,14,15,16} In response to federal legislation, the number of hospitals with a certified EHR rose from 72% (2011) to 94% (2015).¹⁷ For experienced health professionals over the same timeframe, EHR burden has been associated with burnout and reduced professional satisfaction.^{4,18}

We define EHR burden and documentation burden (henceforth *EHR burden*) as the expected load or workload experienced by a health professional (HP) completing necessary tasks included in documentation and EHR interaction (e.g., generation, review, analysis and synthesis of patient data).⁶ (Appendix 3) EHR burden can be challenging to measure.^{19,20} For HPs who have completed training, interventions to mitigate EHR burden, as well as subsequent impacts on clinical practice, satisfaction, and ultimately burnout and wellness have been explored.^{18,21} Much less is understood of trainee EHR burden and how EHR burden experienced by trainees can be addressed.^{22,23,24}

Trainee EHR use, the roles and tasks trainees need to perform in their daily workflow, and time spent in the EHR contributing to healthcare delivery may change through different stages of training.^{22,25,26} EHR access is not universally granted during training,²² if at all.^{22,25} As a result, trainees' experience of EHRs and EHR burden may change as training progresses, and vary across different health professions.^{26,27} Trainees' interactions with data in the EHR can include data capture, data review, data entry, synthesis or generation of impressions in notes or other documents, and interdisciplinary team communication. Models can be used as a descriptive tool in informatics and can be applied to a clinical process to understand tasks and guide improvements in the associated health informatics tools needed to complete those tasks.^{28,29} Models can therefore be used to describe *workflow*, the sequence of tasks performed by individuals in an environment.^{30,31}

Trainees have reported EHR burden has concerning negative impacts²³ on training and time at the bedside directly caring for patients.^{14,16} Trainee perspectives of EHR burden^{16,32,33,28} have been measured through quantitative, qualitative, or a mix of methodologies. Time tradeoffs have been examined using audit log data and direct observations.¹⁴ EHR burden can detract from time spent learning and performing training tasks, such as procedures or

operating room cases for surgical trainees.³³ EHR use may also interfere with the trainee and clinician educator or supervising HP, and have unintended consequences on healthcare delivery.²

In this work, we were interested in understanding how trainee EHR workflow might fit with an existing technology workflow model^{29,31} and the targets of intervention selected by studies that aimed to mitigate or reduce trainee EHR burden. We were interested in studies that measured the trainee perspective of EHR burden.

2 OBJECTIVE

The objective of this work was to develop a model of how interventions to mitigate EHR burden fit within the trainee EHR workflow, henceforth referred to as the *Trainee EHR Burden Model*. To accomplish this objective, we:

- 1) Examined trainee experiences of interventions that aimed to mitigate EHR burden, by performing a scoping review of intervention studies that also measured trainee perspectives of EHR burden.³⁴
- 2) Mapped points of intervention for EHR burden from the scoping review studies to an existing workflow model^{29,31}
 - a) First we categorized included studies by applicable model²⁹ elements. b) Then we adapted the existing workflow model to an EHR-specific trainee workflow and overlaid the EHR burden intervention categories, to develop the *Trainee EHR Burden Model*. We used concept clarification methodology,³⁵ which can be used to adapt an existing model to a different topic area using an iterative process.(Table 1)

3 MATERIALS AND METHODS

We selected an existing conceptual model²⁹ to adapt based on the following criteria: a) described technology workflow, b) included model elements that could map to the 6 domains of EHR burden,^{6,31,36} and c) included different types of intervention points (e.g., interventions that targeted training, usability, institutional culture, or technology). Further, we selected the Unertl workflow elements model²⁹ to adapt, because of its representation of healthcare workflow components including actors, actions and outcomes, incorporating context and temporality.²⁹ The sociotechnical model³⁷ was considered but not selected for adaptation, as it offers some but not all of the categories of factors relevant to trainee EHR burden, and it does not present a visual of workflow. We performed a scoping review of interventions to mitigate trainee EHR burden that measure trainee perspectives regarding EHR burden and/or the intervention's impact on EHR burden. We then applied concept clarification methodology³⁵ to map the scoping review

studies to the existing workflow model,²⁹ to develop the *Trainee EHR Burden Model*. We engaged 4 content expert co-authors (on the EHR and health professional experience of EHR use) for the concept clarification, to review and help refine the model.

3.1 Design and Search Strategy

We applied scoping review³⁴ and concept clarification³⁵ methods to systematically conduct this work.(Table 1) We designed scoping review search strategies (DRL, DW) in consultation with a health science and research librarian (AH) and followed guidance offered by Johanna Briggs Institute Manual for Evidence Synthesis of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Extensions for Scoping Review (PRISMA-ScR).³⁴ We searched four databases (Ovid MEDLINE, Embase, Web of Science and Cochrane) over one week between November and December 2023.(Appendix 1) Dates did not delimit the search. We did not include Google Scholar as a database, as we prioritized reliably reproducible search strategies.

3.2 Study selection, Eligibility Criteria and Data Extraction

We identified studies that examined interventions to mitigate EHR burden that measured trainee experience of EHR burden. Searches included 3 key characteristics: 1) an inclusive mix of terms identifying trainees³¹ from a range of HP fields (e.g., nursing, medicine, pharmacy, physical and occupational therapy, speech language pathology, and allied health professions), 2) terms regarding EHR or electronic medical records,³¹ and 3) terms to highlight *burden*.³¹(Appendix 1)

We used Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia) to collect database search results, support screening, and manage the review and results abstraction process for retrieved studies. (Figure 1) Two authors (DRL, DW) served as two reviewers for each stage of study selection, applying a priori inclusion and exclusion criteria.(Table 2) We (DRL, DW) extracted a range of a priori study characteristics from a final corpus of studies: 1) study objective (primary, and secondary where applicable); 2) study methods and participant numbers; 3) intervention target, (e.g., EHR task target or trainee workflow target, or both); 4) intervention design; 5) focus point of intervention in patient care delivery workflow; 6) trainee healthcare field; and 7) study limitations.(Table 3, Figure 2) Due to the small corpus, for the data extraction stage only, studies were extracted by DRL and DW

synchronously. Results of the corpus were exported from Covidence for detailed analyses. Key observations and findings that inform the subsequent concept clarification are described below.

Inclusion criteria

We identified studies with interventions that focused on trainees or analyzed trainees separately from experienced health professionals.(Table 2) We did not limit the type or structure of interventions, nor the timing of measurement of EHR burden relative to the intervention. Trainee EHR burden measurement could be a primary or secondary aim of the study (e.g., one study had a primary patient safety outcome, with a secondary outcome of measurement of trainee perspectives of EHR burden). Quantitative measures of EHR use such as metrics³⁸ (e.g., time-based metrics, analyses of document characteristics or note length, EHR use, or patient-focused outcomes) were not excluded; but if captured alone, these were not considered measures of trainee experience of EHR use for inclusion. We excluded studies with an abstract only, as reporting of methods was not sufficient to ensure the methods met inclusion criteria. We present a detailed evaluation of limitations of the included studies in section 4.7 below.

Exclusion Criteria

We excluded studies that did not examine trainee perspectives of EHR burden.(Table 2) We also excluded studies if they: 1) conducted observational or descriptive studies of EHR burden or use, or quantified trainee perspectives without evaluating an intervention; or 2) did not report or include study design. We based this criterion on the inability to assume an intervention would positively or negatively impact trainee EHR burden experience without assessment of the trainee perspective.

3.3 Concept Clarification

A concept clarification can be used to analyze and adapt an existing model or framework.³⁵ The first step in our concept clarification of the workflow model was grouping the scoping review corpus by workflow model categories. (Table 4) Intervention studies were categorized using the elements of the existing model, and mapped to develop a trainee workflow.(Figure 2) Next, we mapped categories of EHR tasks, workflow steps and interventions to the Unertl model of workflow.²⁹(Figure 2) The categories of studies were mapped to develop the adapted workflow model,

Trainee EHR Burden Model, representing trainee EHR use with points of intervention for trainee EHR burden.(Figure 3) Because of the inclusive nature of trainee categories, and differing ways trainees in different health professions fields work within the EHR, we anticipated not all stages in the adapted model would be represented by the scoping review corpus nor would they apply to all types of trainees. Finally, we adapted the existing workflow model. We selected five domain expert co-authors with expertise in research, trainees, electronic health records, HP training and experience of EHR use, and EHR burden (CB, ERM, SCR, STR) to provide expert review of the analysis of the corpus in the concept clarification phase. Expert input was obtained and incorporated through 2 rounds of iterative, asynchronous review. The full co-author team achieved consensus on the categories of trainee workflow and the *Trainee EHR Burden Model*.

4 RESULTS

Our 4-database search yielded 820 records,(Figure 1) which we reviewed and iteratively screened to achieve the scoping review corpus of 11 eligible studies for extraction. Thirty-five of 69 studies at the full-text stage were excluded as only an abstract was available. We manually identified each available data point in 11 studies selected for extraction. (Table 3) Individual EHR tasks were often the focus of the intervention (e.g., computerized order entry, entering orders or documentation),^{32,39-42} while other studies focused on shared tasks (e.g., team interdisciplinary rounds, handoff at shift change, general workflow during the day across team members, and interdisciplinary team communication via text paging).⁴³⁻⁴⁸ Five of the eleven studies were conducted prior to 2012,^{32,39,41,44-46} although they still had relevance to the development of the workflow model. These earlier studies examined interventions ranging from handoffs at shift change,⁴⁴ and implementation and training on EHR use,^{32,39,41} to the addition of tablets to morning rounds.⁴⁵

All corpus studies included trainees exclusively in their intervention and analyses. Nine studies focused on physician trainees, ranging in training stage from medical student through residency and post-residency. One study focused on nursing students, and one study examined pharmacy student experiences. (Table 4) Quantitative survey methods were most commonly applied (n = 10), either alone (n = 5), or in combination with other quantitative or qualitative methods (n = 5). Four studies employed direct observation as one arm of the study design, while 2 studies employed qualitative methods to capture trainee experiences of EHR burden. Most studies reported their work was evaluated and either granted exemption or considered to be a quality improvement study by institutional review boards (IRB). Several studies did not report IRB status.

4.1 Concept clarification: Study categories and *Trainee EHR Burden Model*

We then used a concept clarification³⁵ to develop the *Trainee EHR Burden Model*, which identifies points of the trainee EHR workflow to consider for interventions to alleviate EHR burden. Most studies from the scoping review mapped to model elements and points of interventions in the inpatient setting, (Figure 2) resulting in an adapted model that best applies to the inpatient trainee workflow.(Figure 3) Several logical points in trainee workflow not present in the included studies were added to the model (in Figure 2, see boxes without superscript citations). Intervention categories presented in Figures 2 and 3 were limited to those identified in the studies.

Included Sources Examined by Category of Intervention in Trainee EHR Workflow

4.2 Studies of interventions on training and evaluating EHR use

Six studies, published between 1999 and 2018, examined the impact of training interventions or assessing trainees while using EHRs, in a variety of settings and clinical scenarios (e.g., inpatient, ambulatory, operative/surgical setting, pharmacy).^{32,40,42,45,46,48} Five of six studies had a physician trainee focus, with one study of pharmacy trainees.⁴⁵ Publications reported interventions ranging from supporting order entry,³² observing and training on ambulatory EHR use with patients present,⁴³ and expanding EHR exposure and training for pharmacy trainees.⁴⁵ One study⁴² applied a simulated EHR environment (e.g., educational video interventions), with the goal of improving surgical resident trainee efficiency and confidence in core EHR tasks; surveys measured the trainee experience of EHR task completion and confidence levels after simulated procedures. One study⁴¹ applied small incremental training modules related to EHR use and iteratively evaluated trainee experience, which was unique compared with other interventions.

4.3 Study of real-time EHR use during rounds

One controlled mixed methods study⁴³ (time-motion study with a post-intervention survey) included introduction of a novel mobile laptop and associated workflow design to shift emphasis to order-entry and team EHR use during rounds, with the goal of reducing documentation time and improving trainee EHR use experience during the remainder of the day. While the stated primary focus was impacting patient safety, both trainee perspectives of EHR

use and quantitative EHR use data were analyzed. One participant team was exposed to the intervention workflow and tablet, and two teams served as comparison or control arms, using their usual institutional workflow.⁴³

4.4 Studies involving trainee/patient and trainee/interdisciplinary team communication

Two studies examined trainee/patient communication,^{39,46} although we reported results of Lanier (2017)⁴⁶ under Section 4.1 because their focus was also on improving EHR use through training. One source applied pre-post measurements of trainee perspectives and experience of a previously-designed curriculum³⁹ to prepare trainees for patient portal communication prior to functionality implementation.⁴⁹ Trainee attitudes of workload and general message burden were assessed both in anticipation and after use of the portal were elicited.⁴⁹ A quantitative survey⁴⁷ was combined with EHR use data, to evaluate a HIPAA-compliant “EHR-integrated text paging” system intervention in an urban hospital emergency department, designed to improve the quality of information shared with the trainee.⁴⁷ Post-implementation, trainees reported the ability to focus on learning activities without interruption.

4.5 Studies of handoff interventions

One qualitative cohort study with historical controls⁴⁴ introduced an “EMR-generated physician sign-out tool,” conducting open-ended surveys and select interviews 6-months after implementation of the handoff tool intervention to pediatric resident trainees. Trainee perceptions of the impact on workflow included increased satisfaction with the sign-out process and reduced time devoted to what the authors reported as “redundant data-entry.” The authors noted their primary motivation was enhancing safety of patient handoffs, but measured the potential benefits for trainee workflow.

4.6 Studies with home-care documentation focus

One survey study (n = 200 nursing students) assessed an educational curriculum intervention designed to improve home-care nursing student documentation.⁴⁷ Following case-based modules, developed to teach nursing students specific documentation skills, post-completion surveys were administered.

4.7 Limitations of Scoping Review Studies

Most studies included in this scoping review reported a variety of logistical and methodological limitations, utilizing heterogeneous terms to describe study limitations. Several studies reported characteristics of physician trainees rotating between units and across teams as a challenge in study design. The trainee rotations and time on a given service was reported by several studies, including the impact of interdisciplinary or group EHR utilization when designing a control or comparison group. Sample sizes were reported as a limitation in several studies, due to a small number of trainees in a program, and/or because trainees had limited time and availability to participate in intervention research. While participant numbers were reported by most studies, the differential between those invited and those who participated was not reported in several studies.

5 DISCUSSION

We identified 11 intervention studies that aimed to mitigate trainee EHR burden, and assessed and reported the trainee perspective of the intervention. (Table 3) Study methods included qualitative, quantitative, and mixed methods assessments of interventions at various points in the trainee workflow. We developed *The Trainee EHR Burden Model* which can help visualize points in trainee workflow that EHR burden interventions might address. Many *Trainee EHR Burden Model* elements did not have study interventions that mapped to the element, and as previously noted, many studies were over a decade old. The model offers an opportunity to take a broader view of how interventions in future work could be targeted to fit within the trainee workflow, while identifying which elements are currently understudied. Gaps in the literature were visualized more clearly by mapping existing interventions to this new model.

Few studies considered how the intervention fit within the trainee EHR workflow, spanned multiple workflow steps, or studied broad changes to the format or usability of how trainees interact with the EHR. This may be related to complex ways that interdisciplinary teams use EHRs⁴³ as well as institutional environments determining many facets of EHR use that studies acknowledged as limitations.

We identified many studies that presented excellent descriptions of EHR burden or quantifications of its impact, which did not present potential interventions. While a systematic analysis of the excluded studies was not performed, we observed that a large number of *excluded* studies described EHR burden or quantified its impact, but did not offer an intervention to improve trainees' EHR burden.^{26,50-52,53} This anecdotal observation aligns with prior work on

experienced HPs that demonstrated more description in the literature of the impact of EHR burden, than solutions to address it.^{6,54}

This scoping review highlights the challenges studies involving trainees often face, including: 1) rotation of trainees between units or service lines affecting exposure to interventions; 2) learning the EHR while learning clinical fields;⁴² 3) opportunities and challenges related to frequent handoffs between trainees, colleagues and teams.⁴⁴ Teaching trainees how to interact with the patient and computer simultaneously was a novel approach applied by Lanier (2017),⁴⁶ with a goal of affecting both trainee EHR interactions and patient experience. One study required participation of all students who rotated through a class,⁴¹ which had the potential to introduce bias in survey responses.

5.1 Gaps and Limitations

Gaps and Limitations of Scoping Review Included Studies

Despite a broad and deliberate search strategy to elicit studies for a broad range of HP fields, there was a general lack of studies addressing trainee EHR burden. We identified few interventions to mitigate EHR burden (n = 11) and few health professions represented (ie: physician, nursing, and pharmacy), potentially limiting the model applications to other fields. Included studies went beyond descriptions of the burden of EHR use, and the ways in which EHR burden impacts trainees, by offering interventions that often approached a narrow aspect of EHR use or the trainee workflow. We noted the majority of included studies had small sample sizes, focused on the inpatient setting (n = 6), and focused on physician trainees (n = 9). The reporting of limitations in several studies utilized heterogeneous terminology, rendering generalizations across studies more challenging. Studies frequently reported that the structure of health professions training, including trainee availability or lack thereof, impacted research participation. Several interventions were integrated into a required clinical rotation or a curriculum, so several studies might be considered through a lens of quality improvement. The rationale for selection and mix of research methods was less frequently reported by included studies.

Nearly half of the studies (n=5) were conducted prior to 2012.^{32,39,41,44-46} The target of the intervention and the rationale for intervention selection remain of interest in the categorization and model adaptation we performed, however the interventions themselves may have reduced applicability to current workflows.

Limitations of This Study

We performed a broad 4-database search strategy. The lack of MeSH terms for EHR burden or documentation burden can affect search strategies in this domain. We were inclusive of a wide range of potential synonyms and terms for EHR burden. Many studies in the corpus employed quasi-experimental results, so our analyses and extraction of studies captured the topics of interest to the included studies and EHR burden measurements. We anecdotally observed that a large number of excluded studies in nursing, pharmacy, and other HPs presented more observational and descriptive data.^{16,33,55} A focus on intervention studies may not have resulted in a complete list of trainee EHR workflow, which may impact the precision of the resulting model. We included studies from trainees at all stages of training in their health profession. All included studies except one were conducted in the US,⁴⁶ although our search strategy included all English language publications. Lastly, we intentionally did not date-delimit the searches, however as anticipated there is an inflection point after wider implementation of EHRs with federal legislation.¹⁷ Therefore, some earlier studies in our corpus explore functionalities and interventions that may now be integrated into available EHR products and may not require separate consideration. We identify the timeframe of these studies as a gap in the current literature, with nearly half of the studies published over 10 years ago. We note that these topics focused on in the past warrant updated exploration now, but thoughtful consideration of the original studies is still worthwhile.

5.2 How can the identified interventions impact future research?

We recognize that some of the interventions aiming to mitigate EHR burden in older studies may not be relevant today. For example, sign-out tools⁴⁴ are now integrated in some EHRs, so a separate functionality may not be necessary. However, the fact that handoffs were identified as a point of interest may still be of interest for generation of the *Trainee EHR Burden Model*, given the role of handoffs in improving patient safety. Similarly, an EHR-integrated paging system⁴⁷ may be less relevant today than when this study was published in 2018, but team communication and the impact on task-switching remains a point of interest.⁵⁶ Several interventions involved additional training on existing systems, or assessing functionalities that were implemented in support of patient care. Limited resources were cited by several studies as both a limitation to wider technology adoption⁴³ and the impacting studies with large sample sizes.

Increasing available hardware or adding access to mobile devices was offered by several interventions. However, if usability is a similar EHR burden concern for trainees as for experienced HP,⁶ then increasing access to the

same EHR may not address the greater opportunity to address what might be unique about how trainees interact and consume EHR data. We reflect some user-centered design approaches might require institutional or interdisciplinary team level of intervention (e.g., interventions that approach tasks of documenting, team-based communication, and order entry could reduce the challenge of redundancy reported by a number of studies).

5.3 *Trainee EHR Burden Model: Implications and next steps*

Modeling clinical workflow can help identify usability opportunities during EHR implementation.⁵⁷ We developed the *Trainee EHR Burden Model* with the aim of providing a framework for researchers, operational leaders and EHR designers to develop interventions to mitigate trainee EHR burden. The Unertl model²⁹ has strengths in terms of clearly identifying a workflow for health professionals, and model elements aligned well with the development of the adapted *Trainee EHR Burden Model*. We recognize the limited number of studies identified to categorize and map to adapt the model. However, given the current lack of a model of EHR burden for trainees, this work could serve as a foundation. When compared with interventions available for experienced HP, we identified gaps for trainees. For example, we noted a lack of usability and human factors engineering applied in solution development to improve usability and few interventions tried to improve presentation of clinical data to trainees.

Further intervention studies in different clinical settings, team structures, and health professions could enable development of *Trainee EHR Burden Models* applied to those settings. A priori, we anticipated this model could help researchers be more systematic and deliberate in designing future interventions designed to mitigate trainee EHR burden. Many included studies did not describe a rationale for picking the point of workflow examined. We see the opportunity for the *Trainee EHR Burden Model*(Figure 3) and its elements to encourage future studies to situate the measurement and research of trainee EHR burden within the context of trainee workflow. For example, if developing an intervention on entering orders, researchers and operational leaders could take into account the *context* (e.g., level of seniority and training experience, potential role of simulation), the *aggregation* (e.g., team structure), the *temporality* (e.g., clinical setting and day/night shift), and measure potential outcomes (e.g., patient safety and trainee experience of EHR burden).

6 CONCLUSION

We identified interventions that mitigate health professions trainee EHR burden, and then developed an adapted *Trainee EHR Burden Model*, building on an existing workflow model.²⁹ Further studies are needed to develop interventions for model elements that have not yet been studied. This model could be further adapted to other clinical settings and health professions. We recognize that despite a broad search strategy with deliberate sampling inclusive of all trainees, we did not identify interventions for a range of health professions, and further work is warranted to understand potential interventions in those fields. We consider this scoping review a call to action for further studies to explore interventions that could mitigate EHR burden.

CLINICAL RELEVANCE STATEMENT (3 sentences)

From this scoping review we identified few interventions targeted to mitigate health professional trainee electronic health record (EHR) burden. Of the included studies, many used quasi-experimental design, and they had potential limitations including generalizability, measurement bias, selection bias, and lack of control or comparator groups. We adapted a model to categorize potential points of intervention to mitigate EHR burden for trainees in the concept clarification phase. Research is needed to evaluate interventions at various stages of the health professional trainee workflow.

Multiple Choice Questions:

- 1) Question: Health professions trainees (trainees) perform similar electronic health record tasks during their training, in preparation for post-graduate careers:
 - a. True, most health professional trainees can access all EHR tasks they will need after training.
 - b. True, but only a few health professions allow EHR access during stages of training.
 - c. False, trainees are not allowed to access the EHR during training.

Answer: Choice b.

Explanation: We found that trainee access to the EHR varies across health professions. In particular, pharmacy trainees may have reduced access to the same EHR tasks they may need to perform after entering the workforce. A number of the EHR burden-mitigating interventions we identified were focused on applying specially-designed curricula⁴⁵ or simulation training to the EHR setting, to help trainees prepare for their post-graduate careers.

2) Question: The unique impacts of EHR burden experienced by health professions trainees are well-understood for the following fields:

- a. Nursing
- b. Physician
- c. Allied health professions/PA
- d. Pharmacy
- e. None of the above

Answer: Choice e.

Explanation: EHR burden⁶ is well-understood for an experienced health professional (HP), including the links to stress and burnout. Trainees in health professions are noted to be different than experienced HPs, as they are both learning their chosen profession while performing EHR tasks. EHR burden has been described as existing in HP trainee populations,⁴⁷ but few studies identify solutions or interventions to mitigate trainee EHR burden. We identified 11 interventions through a scoping review, (Table 4) and mapped these studies to develop an adapted workflow model of trainee inpatient activities (see Figure 2). Future work is needed to develop targeted interventions to mitigate trainee EHR burden, addressing the time-tradeoff for other training-related activities due to EHR burden.

3) Question: The following factors unique to health professions trainees *may* impact the study design of interventions to mitigate trainee EHR burden:

- a. Scheduling of trainee rotations
- b. EHR tasks trainees' access during training
- c. Health professional roles on the clinical team
- d. The size of a health professions training program

e. All of the above

Answer: Choice e.

Explanation: Studies included in the scoping review reported a variety of factors which impacted their study designs, related to HP trainee factors. The size of a training program, the variable availability of HP trainees during different shifts and days, and the variable access to EHR tasks and roles were cited. Further, as trainees are functioning within an interdisciplinary team, several studies that used a control group needed to control on the level or unit of the whole team because of trainee rotation schedules.

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Conflict of Interest:

The authors have no conflicts of interest to report related to this work. ERM reports grants and contracts from NIH, Agency for Healthcare Research and Quality (AHRQ), and American Medical Association (AMA) unrelated to this analysis. ERM reports receiving stock options/equity for serving as an advisor for Iolite health, Inc. SCR reports grant funding from AHRQ, NINR, and a leadership role for AMIA (Chair of AMIA's 25x5 Task Force) unrelated to this analysis. VM funding from NIH and AHRQ unrelated to this analysis.

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Contributorship Statement:

DRL conceptualized the project with the advising of DW and VM, as her independent study (2021, VM) and capstone (2023-2024, DW and VM) faculty advisors. The authors (DRL, DW, and AH) designed the search strategies. DRL and DW independently evaluated the titles and abstracts for inclusion and exclusion criteria. Data were extracted by DRL and DW in joint sessions, due to the small corpus. All authors contributed to the concept clarification phase. The manuscript was drafted by DRL, with detailed feedback from DW, VM for early drafts and all co-authors for later drafts. The workflow model was adapted by DRL and DW, was then reviewed in detail by expert co-authors (CB, ERM, SCR, and SR). The complete manuscript (drafts and final version) was reviewed in detail by all co-authors.

Protection of Human and Animal Subjects:

Human and/or animal subjects were not included in the project.

Data Availability Statement:

The data underlying this article including the detailed search strategy are available in the article and in its online supplementary appendix materials.

Disclaimer:

The contents of this manuscript represent the view of the authors and do not necessarily reflect the position or policy of the U.S. Department of Veterans Affairs or United States Government.

Appendix 1: Search Strategies for Scoping Review

Source: The authors developed and conducted this search strategy of 4 databases in consultation with a faculty research librarian. Searches conducted between November and December 2023.

Alt Text: Table format of the scoping review search strategies for the 4 databases. The searches for several databases include incremental or smaller searches that were gradually combined to achieve the final result from that database.

Appendix 2: Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

Appendix 3: Glossary of terms related to Trainees, Workflow, and Documentation burden

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Legends for Tables and Figures:

Table 1:

Title: Steps for Developing the *Trainee EHR Burden Model* from Scoping Review Studies

Source: The authors describe the steps taken to develop the Trainee EHR Burden Model, including aligned objectives, methods, actions and results and findings leading up to model finalization.

Table 2:

Title: Title and Abstract Review Criteria, Screening Inclusion and Exclusion Criteria

Source: The authors developed and conducted this screening strategy applying the PRISMA-Scr guidance, with the results of four databases, to identify studies with interventions to mitigate EHR burden for health professions trainees. See Appendix 1 for the Search Strategies.

Table 3:**Title:** Characteristics of Included Studies with Interventions Aimed at Mitigating Trainee EHR Burden**Source:** The authors extracted study characteristics, including location of study by country, study participants and field of health professions trainees, as well as methods applied to study the intervention. ^ Refers to measured primary objective in the study (i.e., 1) Examine trainee perspective or experience of EHR burden, 2) Patient safety or regulatory compliance, or 3) Trainee EHR use / usability.**Table 4:****Title:** Categories of interventions and characteristics of studies aiming to mitigate Trainee EHR Burden**Source:** The authors extracted both the study objectives in categories to align with the existing workflow model. Study objectives and narrative text in prose format was extracted from each study in the authors' wording. The scoping review included studies (n = 11) were each categorized in terms of the point of intervention or EHR activity that would map to the existing workflow model.**Figure 1:****Title:** PRISMA Flow Diagram of Scoping Review**Source:** The authors present their analysis of the literature extracted during the Scoping Review. The sequential stages of the search are included, as well as the exclusion criteria for each key stage.**Figure 2:****Title:** The Scoping Review Corpus Workflow Map**Source:** The authors analysis of the scoping review corpus, categorizing EHR-related tasks that can contribute to EHR burden for health professional trainees. Interventions in included studies were also examined and categorized.**Figure 3:****Title:** *Trainee EHR Burden Model* - Concept Clarification of Unertl Workflow Model for Trainee EHR Burden Interventions²⁷**Source:** The authors analysis of the scoping review corpus, categorized included studies and then mapped those categories to the Unertl workflow model to adapt the model to the health professional trainee workflow (*Trainee EHR Burden Model*), with recognition of potential points of intervention on the HP trainee workflow to mitigate EHR burdenTable 1: Steps for Developing the *Trainee EHR Burden Model* from Scoping Review Studies

Study Objective	Steps for Objective 1:	Steps for Objective 2:	
	Examined trainee experiences of interventions that aim to mitigate EHR burden	Developed a model of points of intervention on EHR burden by examining trainee EHR use workflow	
		a) Map and Categorize scoping review sources by elements of existing model ²⁹	b) Develop <i>Trainee EHR Burden Model</i> (adapted model of trainee EHR workflow with overlaid categories of EHR burden interventions)
Methods	Scoping Review	Concept Clarification	Concept Clarification
Actions	*Develop search strategies *Conduct search *Extract study characteristics (e.g., health profession, study type, intervention)	Categorize scoping review studies to elements of existing workflow model ^Conduct one round of asynchronous review of Categories	Map categories of studies to existing workflow model, to develop <i>Trainee EHR Burden Model</i> (Figure 3) ^Conduct 2 rounds of review to refine <i>Trainee EHR Burden Model</i> (Figure 3)
Results & Findings	Scoping review synthesis yields a set of interventions aimed at mitigating trainee EHR burden	Categories of EHR tasks by elements of model (Table 4, Figure 2) Gaps in study interventions identified	Identify Adapted Model Gaps and opportunities for future work Final <i>Trainee EHR Burden Model</i>

Table 2: Title and Abstract Review Criteria, Screening Inclusion and Exclusion Criteria

Title and Abstract Review Criteria	
Inclusion	Exclusion
<p>Population</p> <ul style="list-style-type: none"> • Study involves trainees as a focus (any discipline)* • *Exception to trainee only focus: Trainees are analyzed separately but studied in combination with experienced HP • Trainee perspective and experience of EHR burden is the focus (i.e., not administrative, regulatory, task completion, etc.) <p>Intervention</p> <ul style="list-style-type: none"> • Examines an intervention or some effort to mitigate EHR burden as part of study <p>Study characteristics</p> <ul style="list-style-type: none"> • Trainee-related outcomes including their perspective are measured and reported 	<p>Population</p> <ul style="list-style-type: none"> • Trainees not analyzed separately from other health professionals (HP) • “resident” term in work applied to <i>inhabitant</i> of a facility or geographic location, not applied to HP trainee • Different topic relating to the EHR • Different topic unrelated to informatics • Documentation not related to healthcare <p>Intervention</p> <ul style="list-style-type: none"> • No intervention to mitigate EHR burden • Only <i>describes</i> or quantifies issue of EHR burden on trainees (without effort to mitigate) • Does not measure trainee perspective of EHR burden as part of study <p>Study characteristics</p> <ul style="list-style-type: none"> • Not a study (i.e., editorial, perspective, white paper, letter to editor)
Full Text Review Criteria	
Inclusion	Exclusion
<p>Context is related to health professional trainees AND the criteria below are met:</p> <ul style="list-style-type: none"> • Trainee perspective on EHR burden evaluated using any form of measurement • Measurement includes EHR perspective assessed from trainee, not indirectly through EHR metrics, EHR usage, observation or other data (although other measures can also be captured in study outcomes) 	<ul style="list-style-type: none"> • Work is an abstract only • Primary outcome of trainee compliance, unclear impact on trainee EHR burden • Primary outcome clinical (patient-related), unclear impact on trainee EHR burden • Primary outcome patient safety, unclear impact on EHR burden • Intervention involved shifting EHR tasks to another clinical team member (i.e., shifting of burden) • Trainee data not analyzed separate from experienced HP • Trainee EHR burden not directly measured or examined • Trainee perspective regarding EHR burden was not fully assessed or reported • Manuscript not published in English

Table 3: Characteristics of Included Studies with Interventions Aimed at Mitigating Trainee EHR Burden

Study (year)	Work conducted	Country	Participant reported	Participants per Study Arm	Health Professional	Objective Category [^]	Methods
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published)	(years)		in source				
Ash, J (1999)	Before 2000	USA	Yes, but only for some study aims	<p><u>Observation:</u> Unclear, 9+ across sites, number of sites not specified</p> <p><u>Focus groups:</u> 2 focus groups across sites, numbers of participants and sites not specified</p>	Physician	(1) Examine trainee perspective or experience of EHR burden	direct observation; qualitative (including open-ended survey or interview)
Balch, H (2022)	Since 2020	USA	Yes	<p><u>Total participants:</u> 34 interns, 20 senior residents. Trainees considered as individuals and in teams.</p> <p><u>Intervention:</u> -Intervention group: One team, 13 interns, 7 senior residents rotated in/out of team over study -Control groups: Two teams, total of 21 interns and 13 senior residents rotated in/out of team over study.</p> <p><u>Time-motion study of rounding:</u> 14 intern days (160.5 hours) -Intervention group: 7 intern days -Control groups: 7 intern days -Number of participants observed per rounding not specified.</p> <p><u>Audit log study:</u> -Then survey and audit log data collected</p> <p><u>Post-intervention survey:</u> Participants not specified</p>	Physician	(2) Patient safety or regulatory compliance	quant survey; quant audit logs; direct observation
Bernstein, J (2010)	2001-2010	USA	Yes, but only for some study aims	<p><u>Survey:</u> 31 of (52%) pre/post survey</p> <p><u>Log data:</u> Participants not specified</p>	Physician	(1) Examine trainee perspective or experience of EHR burden	quant audit logs; qualitative (including open-ended survey or interview)
Crotty, B (2018)	2011-2015	USA	Yes	<p><u>Questionnaire:</u> -133 of 159 (84%) pre-curriculum questionnaire -122 of 159 (77%) post-curriculum and implementation questionnaire -108 of 159 (68%) linked pre & post responses</p>	Physician	(1) Examine trainee perspective or experience of EHR burden	quant survey
Frenzel, J (2010)	2001-2010	USA	Yes	<p>-89 of 94 (95%) pre-course survey -66 of 94 (70%) post-course survey</p>	Pharmacist	(1) Examine trainee perspective or experience of EHR burden	quant survey; direct observation
Johnson, E (2021)	2016-2020	USA	Yes, but only for some study aims	<p><u>Training:</u> -Number of participants not specified, of 26 invited</p> <p><u>Survey:</u> -Iterative Pre-Training Surveys: Not specified -Iterative Post-Training Surveys:</p>	Physician	(3) Trainee EHR use / usability	quant survey

				Not specified			
Lanier, C (2017)	2011-2015	Switzerland	Yes, but only for some study aims	<u>Survey:</u> -17 of 27 (63%) pre-intervention survey -17 of 27 (63%) post-intervention survey <u>Video recorded encounters:</u> -142, number of distinct persons participating in recorded sessions not specified -73 pre-intervention recordings -69 post-intervention recordings	Physician	(1) Examine trainee perspective or experience of EHR burden	quant survey; direct observation
Lapointe, R (2018)	2016-2020	USA	Yes, but only for some study aims	<u>Survey:</u> 25 of unspecified invited participants	Physician	(1) Examine trainee perspective or experience of EHR burden	quant survey
Nokes, K (2012)	2011-2015	USA	Yes	200, mandatory completion after course-related education module	Nurse	(1) Examine trainee perspective or experience of EHR burden	quant survey
Walsh, C (2012)	2011-2015	USA	Yes, but only for some study aims	<u>Survey:</u> 62 of 130 (48%) post-implementation survey	Physician	(3) Trainee EHR use / usability	quant survey
Zoghbi, V (2018)	2016-2020	USA	Yes	<u>Study:</u> 11 of 15 (73%)	Physician	(1) Examine trainee perspective or experience of EHR burden	quant survey; quant audit logs; direct observation

Table 4: Categories of interventions and characteristics of studies aiming to mitigate Trainee EHR Burden

Study (year published)	Methods	Objective Category	Objective (Prose)	Extracted Point of Intervention or Activity [Categorizing model element step]
Ash, J ^P (1999)	direct observation; qualitative (including open-ended survey or interview)	(1) Examine trainee perspective or experience of EHR burden	From Abstract: "Objective: Describe the perceptions of house staff physicians about their experience using computerized physician order entry (POE) in hospitals. Methods: Qualitative study using data from participant observation, focus groups, and both formal and informal interviews."	Computerized order entry (CPOE), [Orders]
Balch, H ^P (2022)	quant survey; quant audit logs; direct observation	(2) Patient safety or regulatory compliance	From Abstract: "Objective: To improve resident efficiency through a novel workflow using mobile laptops and modified rounding-in-flow."	Morning interdisciplinary inpatient rounds, [Pre-rounding, Rounding]
Bernstein, J ^P (2010)	quant audit logs; qualitative (including open-ended survey or interview)	(1) Examine trainee perspective or experience of EHR burden	From introduction: "We therefore predicted that the creation and introduction of an EMR-generated physician sign-out tool would be well received, given its automated data transfer features and remote accessibility. This article describes the impact of implementing	Handoff or sign-out at shift-change, [Handoff]

			<p>such a tool at our hospital on physician perception of workflow and satisfaction with the sign-out process.”</p> <p>From methods: “To determine the effect of sign-out document functionality within the EMR, we conducted a cohort study using historical controls at the main campus of LPCH. LPCH is a 272-bed tertiary care women’s and children’s hospital affiliated with Stanford University and is located in Palo Alto, California.”</p>	
Crotty, B (2018) ^P	quant survey	(1) Examine trainee perspective or experience of EHR burden	<p>From abstract: “We assessed anticipatory attitudes about open notes and explored factors influencing residents’ propensity toward note transparency.”</p> <p>From introduction: “As open notes spread nationally, we sought to understand residents’ perceptions of anticipated risks and benefits to their patients and to themselves, in terms of workload and education. We anticipated that a better understanding of these issues could help inform residency programs in the transparency era.”</p>	Patient portal communication, [Outpatient visit]
Frenzel, J ^{Pharm} (2010)	quant survey; direct observation	(1) Examine trainee perspective or experience of EHR burden	From abstract: “Objective. To develop, implement, and evaluate the use of electronic medical records (EMRs) in disease state management activities to teach pharmacy students patient-centered care skills.”	EHR training and EHR use, during disease-based learning, [Didactics]
Johnson, E ^P (2021)	quant survey	(3) Trainee EHR use / usability	<p>From introduction: “Our hypothesis was that increased peer-led EHR training could result in increased efficiency, thereby decreasing burnout and improving resident wellness.”</p> <p>From methods: “Within our Family Medicine residency over November 2019 to February 2020, we implemented two major interventions designed to educate our 26 residents on our outpatient EHR (Athena) and thereby increase efficiency and improve wellness.”</p>	EHR training and EHR use in outpatient setting, [Outpatient visit]
Lanier, C ^P (2017)	quant survey; direct observation	(1) Examine trainee perspective or experience of EHR burden	From introduction: “The aim of our study was to assess the impact of training on EHR-related communication skills of residents with real patients during the first 10 min of the clinical encounter. We chose to focus on the first 10 min because we have observed that our residents tend to use the EHR mainly at the beginning of the encounter. In particular, we wanted to explore how EHR use changed when patients introduced psychosocial issues.”	EHR training and EHR use during outpatient encounter, including interaction with patient, [Outpatient visit]
Lapointe, R ^P (2018)	quant survey	(1) Examine trainee perspective or experience of EHR burden	From abstract: “We developed and implemented a HIPPA-compliant, EHR-integrated text paging at a busy 591-bed urban hospital. Access was granted to unit clerks, nursing staff, case managers, and physicians. Senders could either send a traditional telephone number page or a text	Interdisciplinary team communication, inpatient, [Clinical tasks]

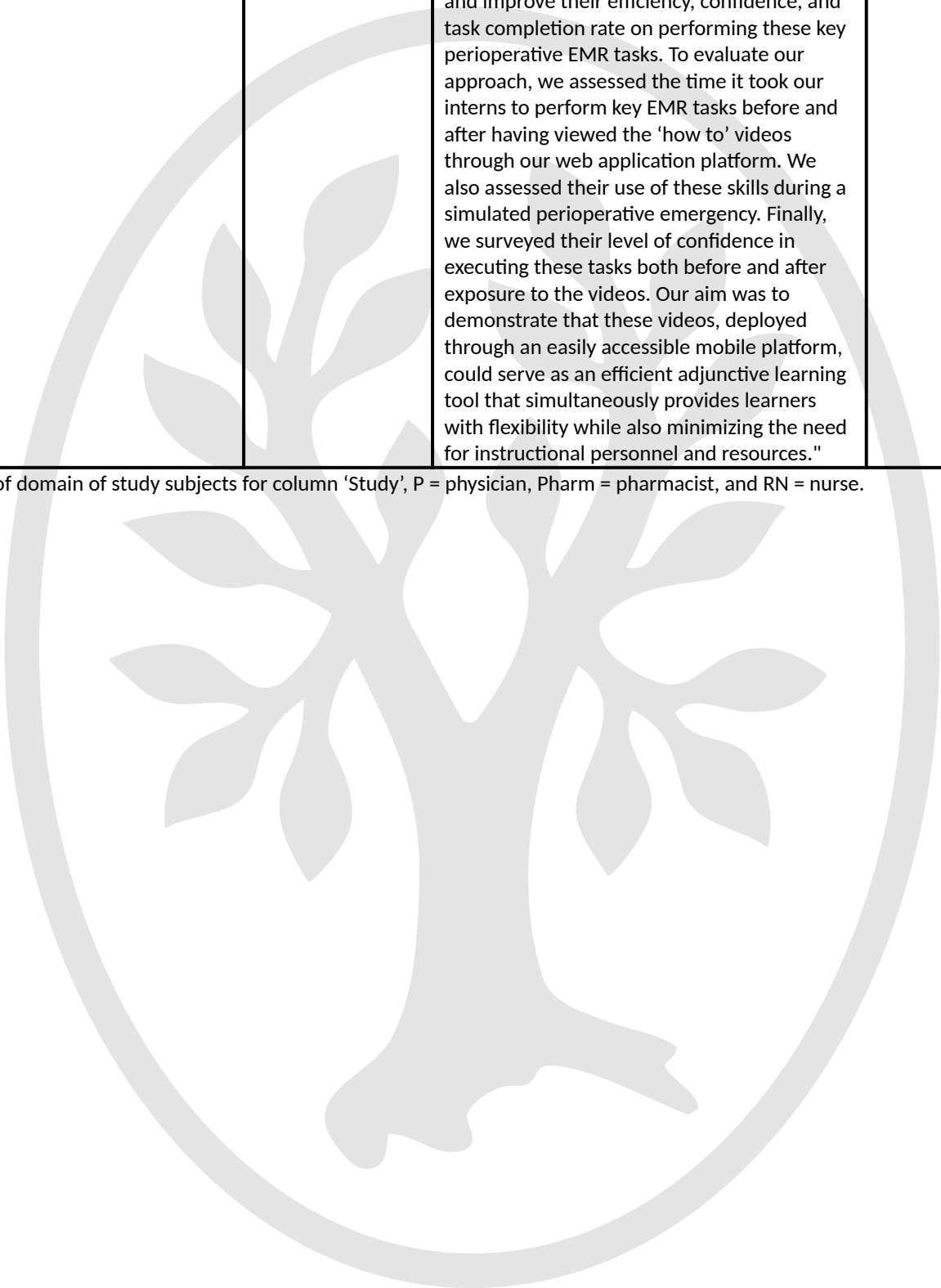
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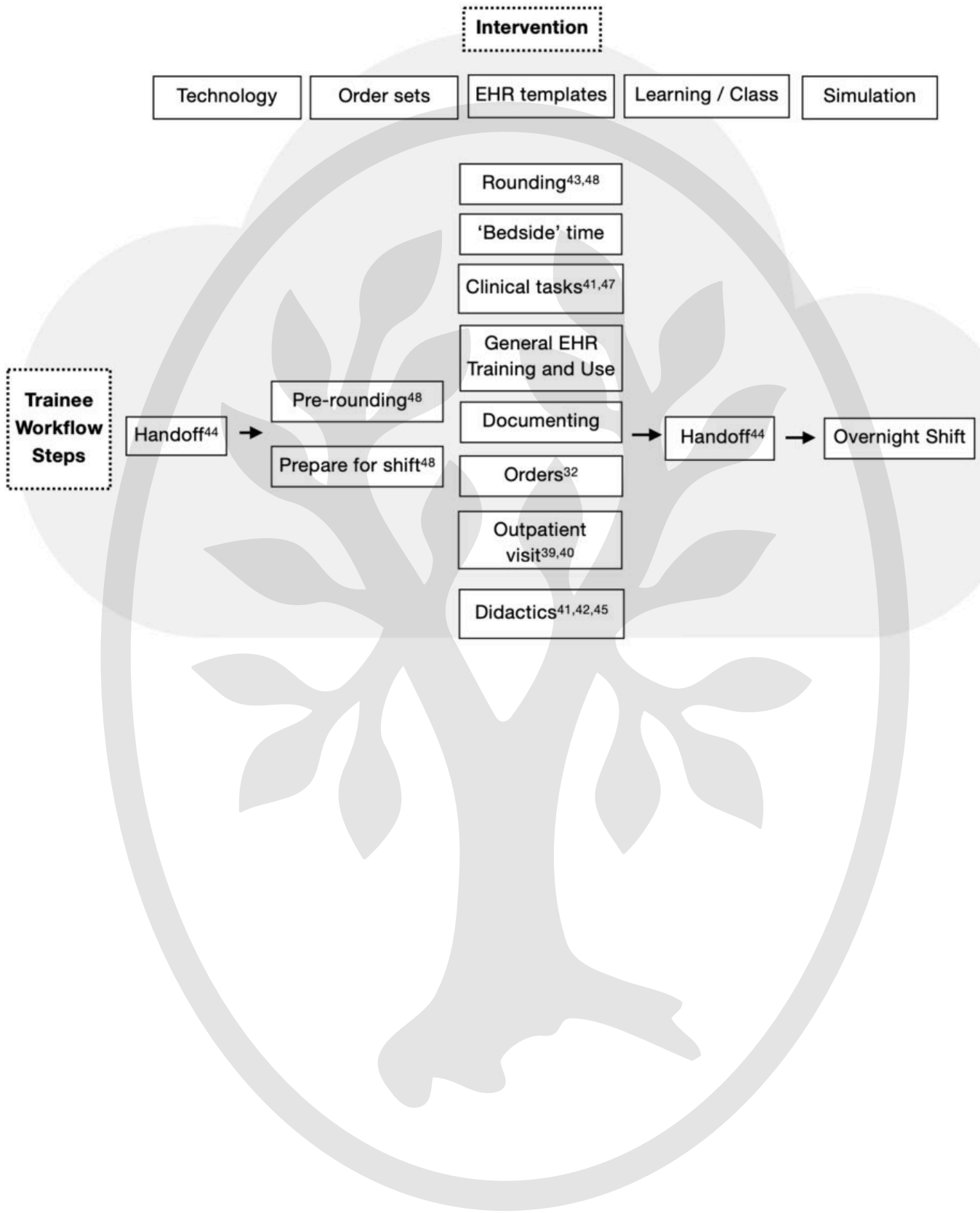
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			<p>page through our EHR. The recipient could then either acknowledge receipt of the page or take appropriate actions. Afterward, Internal medicine residents were polled on overall satisfaction difference between basic phone based numeric paging and the enhanced EHR text paging system."</p> <p>From Methods: "In an attempt to foster improved communication channels, we developed and implemented a new text-paging system to supplement the current traditional system. Residents and IT staff worked together to create text paging through our existing EHR to send a HIPAA-compliant and secure text page. "</p>	
Nokes, K ^{RN} (2012)	quant survey	(1) Examine trainee perspective or experience of EHR burden	<p>From abstract: "Modules were developed to teach EHRS skills using a case study of a homebound person requiring wound care and the Medicare-required OASIS documentation system. This article describes the development and implementation of the module for an upper-level baccalaureate nursing program located in New York City."</p> <p>From body of manuscript: "Improved documentation of home health care through nursing student educational intervention." "External funding supported the development of an educational innovation through a partnership between a home care agency staff and nursing faculty. Modules were developed to teach EHRS skills using a case study of a homebound person requiring wound care and the Medicare-required OASIS documentation system. This article describes the development and implementation of the module for an upper-level baccalaureate nursing program located in New York City."</p>	Education around required documentation in home healthcare setting, [Clinical tasks]
Walsh, C ^P (2012)	quant survey	(3) Trainee EHR use / usability	<p>From introduction: "The Department of Medicine at Columbia University Medical Center provided tablet computers (Apple iPads) to medicine house staff to provide mobile access to the necessary tools of the EHR. The integration of tablet computers into the clinical workflow as well as obstacles to the use of these devices will be discussed."</p> <p>From methods: "The iPads provided a new interface to browse, search, and download these articles. This application was also deployed on devices at launch. A subjective survey was administered six months after provision of the Apple iPads on the house staff service."</p>	Evaluation of workflow and general EHR use with addition of new technology (tablet), [Rounding, Clinical tasks]
Zoghbi, V ^P (2018)	quant survey; quant audit logs; direct observation	(1) Examine trainee perspective or experience of EHR burden	<p>From abstract: "We hypothesized that exposure to these videos would lead to increased resident efficiency and confidence in performing essential perioperative tasks, ultimately leading to improved clinical</p>	EHR training and EHR use, simulated EHR tasks including instructional videos, [Clinical tasks]

			<p>performance."</p> <p>From introduction: "We hypothesized that exposing our interns to these novel "how to" videos would enhance interns' clinical performance on the simulated emergencies and improve their efficiency, confidence, and task completion rate on performing these key perioperative EMR tasks. To evaluate our approach, we assessed the time it took our interns to perform key EMR tasks before and after having viewed the 'how to' videos through our web application platform. We also assessed their use of these skills during a simulated perioperative emergency. Finally, we surveyed their level of confidence in executing these tasks both before and after exposure to the videos. Our aim was to demonstrate that these videos, deployed through an easily accessible mobile platform, could serve as an efficient adjunctive learning tool that simultaneously provides learners with flexibility while also minimizing the need for instructional personnel and resources."</p>	
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Key: In terms of domain of study subjects for column 'Study', P = physician, Pharm = pharmacist, and RN = nurse.





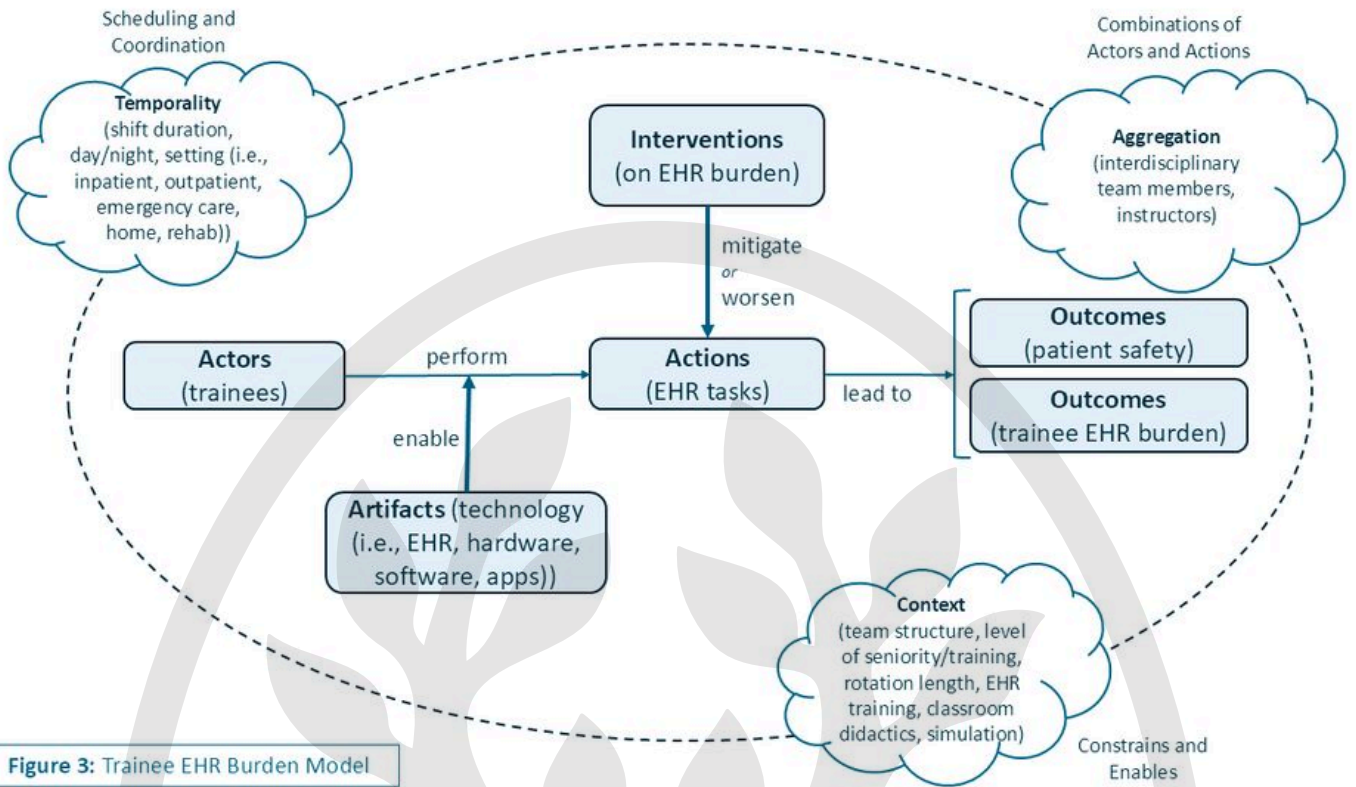


Figure 3: TraineE EHR Burden Model