

Supplemental Digital Appendix 1

Search Strategy

Review query

MEDLINE search via PubMed

((*"Medical Records Systems, Computerized"[Mesh] OR "electronic health records"[Mesh] OR "electronic medical record*" OR "electronic health record*" OR "EMR" OR "EHR" OR "Enterprise Data Warehouse" OR "EDW" OR "Information Management System" OR "Information System"*)
AND

("Education, Medical, Graduate"[Mesh] OR "graduate medical education" OR "resident" OR "residents" OR "residency" OR "residencies" OR Intern[tiab] OR Interns[tiab] OR Internship OR "house staff" OR "house officer*" OR fellow* OR "junior doctor")*))
AND

(("1946"[Date - Publication] : "2021/12/31"[Date - Publication]))

Searched on 2022-01-01, returned 3540 results.

Pilot queries of other databases

Embase search

('electronic medical record system'/exp OR 'electronic health record'/exp OR "electronic medical record" OR "electronic health record*" OR "EMR" OR "EHR")*
AND

('residency education'/exp OR "graduate medical education" OR "resident" OR "residents" OR "residency" OR "residencies" OR Intern:ti,ab OR Interns:ti,ab OR Internship OR "house staff" OR "house officer*" OR fellow*)*
AND [*<1966-2021*]/py

Searched on 2022-01-01, returned 5095 results.

First 100 results reviewed (according to Embase “Most Relevant” sort order).

3 pertinent results identified, all duplicates from MEDLINE query.

Web of Science search

ALL=((("electronic medical record" OR "electronic health record*" OR "EMR" OR "EHR") AND ("graduate medical education" OR "resident" OR "residents" OR "residency" OR "residencies" OR "Interns" OR "Interns" OR "Internship*" OR "house staff" OR "house officer*" OR fellow*))*
AND Publication Date 1946-01-01 to 2021-12-31

Searched on 2022-01-01, returned 20,164 results.

First 100 results reviewed (according to Web of Science “Most Relevant” sort order).

9 pertinent results identified, all duplicates from MEDLINE query.

Supplemental digital content for Fischer Lees A, Beni C, Lee A, et al. Uses of electronic health record data to measure the clinical learning environment of graduate medical education trainees: A systematic review. Acad Med.

ERIC and CINHAL search via EBSCOhost

("electronic medical record" OR "electronic health record*" OR "EMR" OR "EHR" OR "Enterprise Data Warehouse" OR "EDW" OR "Information Management System" OR "Information System")*

AND

(DE "Graduate Medical Education" OR "graduate medical education" OR "resident" OR "residents" OR "residency" OR "residencies" OR "Intern" OR "Interns" OR "Internship" OR "house staff" OR "house officer*" OR fellow* OR "junior doctor")*

AND Publication Date 1946-01-01 to 2021-12-31

Searched on 2022-01-01, returned 1491 results.

First 100 results reviewed (according to EBSCOhost "Most Relevant" sort order)

7 pertinent results identified, all duplicates from MEDLINE query.

Supplemental Digital Appendix 2

Studies Included in the Review

Author	Theme	Competency	Attribution method	Trainee	Synopsis
Bachur et al., 2008 ⁶	Condition Experience	PCPS	Encounter provider	Pediatric EM fellows	Proof-of-concept measurement of longitudinal clinical exposure
Nagler et al., 2006 ⁷	Condition Experience	PCPS	Encounter provider	Pediatric EM fellows	Automatically generate case logs from EHR
Sequist et al., 2005 ⁸	Condition Experience	PCPS	Encounter provider	IM residents	Continuity clinic exposure is highly variable
Braunstein et al., 1977 ⁹	Condition Experience	PCPS	Encounter provider	FM residents	Continuity clinic exposure, with an aim to identify and fill gaps in experiential learning
Dickie et al., 1976 ¹⁰	Condition Experience	PCPS	Encounter provider	FM residents	Quarterly feedback of clinical exposure
Li et al., 2018 ¹¹	Condition Experience	PCPS	Encounter provider	EM residents	Pediatric case exposure is below external standards
Douglass et al., 2019 ¹²	Condition Experience	PCPS	Encounter provider	EM residents	Clinical exposure by acuity level, chief complaint, and PGY
Bischof et al., 2019 ¹³	Condition Experience	PCPS	Encounter provider	EM residents	Clinical exposure (compared to weighting on in-training exam)
Loftus et al., 2021 ¹⁴	Condition Experience; Procedural Experience	PCPS	Encounter provider	EM residents	Pediatric case exposure is highly variable and below external standards
Hripcsak et al., 2004 ¹⁵	Condition Experience	PCPS	Note author; Team; Encounter provider	IM residents	Longitudinal clinical exposure across outpatient, inpatient, and ICU rotations
Rajkomar et al., 2017 ¹⁶	Condition Experience	PCPS	Note author	IM intern	Inpatient clinical exposure is highly variable
Ellsbury et al., 1987 ¹⁷	Condition Experience; Continuity of Care	PCPS; SBP	Encounter provider	FM residents	Clinical exposure and continuity of care are highly variable
Tindall et al., 1975 ¹⁸	Condition Experience	PCPS	Encounter provider	FM residents	Clinical exposure with PBLI-focused feedback
Mittiga et al., 2010 ¹⁹	Condition Experience	PCPS	Encounter provider	Pediatric residents	Clinical exposure in ED is below external standards
Levin et al., 2017 ²⁰	Condition Experience	PCPS	Note author	Pediatric residents	Proof-of-concept heat map of inpatient ICD-10 codes
Yarahuan et al., 2021 ²¹	Condition Experience	PCPS	Note author	Pediatric residents	Inpatient condition experience, and changes with COVID-19
Geanacopoulos et al., 2021 ²²	Condition Experience	PCPS	Note author; Ordering provider	Pediatric residents	Inpatient condition experience, and changes with COVID-19
Seufert et al., 2011 ²³	Procedural Experience	PCPS	Note structured data	EM residents	Procedure logging via procedure note template
Ban et al., 2017 ²⁴	Procedural Experience	PCPS	Note author	Residents (unspecified)	Procedure note template use, with letters sent to noncompliers

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Anyanwu et al., 2021 ²⁵	Procedural Experience	PCPS	Note structured data	Cardiology fellows	Procedure logging via procedure note template
McGinn et al., 2020 ²⁶	Procedural Experience	PCPS	Note structured data	Anesthesiology residents	Procedural experience, EHR vs manual logging
Wanderer et al., 2013 ²⁷	Procedural Experience	PCPS	Unspecified	Anesthesiology residents	Case assignment tool for use by attending, using trainee preferences and procedure experience
Pregnall et al., 2021 ²⁸	Procedural Experience	PCPS	Unspecified	Anesthesiology residents	EHR-embedded reminder to manually log cases
Simpao et al., 2011 ²⁹	Procedural Experience	PCPS	Note structured data	Anesthesiology residents	Procedural experience, EHR vs manual logging
Naik et al., 2017 ³⁰	Procedural Experience	PCPS	Note structured data	GS interns	Procedural experience, EHR vs manual logging
Balla et al., 2016 ³¹	Procedural Experience	PCPS	Medical record number; Date	GS residents	Procedural experience, accuracy of manual coding compared with attending codes in EHR
Greyling et al., 2018 ³²	Procedural Experience; Medical Knowledge	MK; PCPS	Report author	Radiology residents	Longitudinal volume of radiographic studies, measured through the EHR
Rohrbaugh et al., 2009 ³³	Prescribing Experience	PCPS	Ordering provider	Psychiatry residents	Outpatient variation in prescription orders by medication class
Rakofsky et al., 2017 ³⁴	Prescribing Experience	PCPS	Ordering provider	Psychiatry residents	Outpatient variation in prescription orders by medication class and self-reported confidence
Kurtzman et al., 2017 ³⁵	Appropriate Testing	PBLI	Ordering provider; Team	IM residents	Inpatient lab utilization dashboard with evaluation of resident engagement
Dine et al., 2010 ³⁶	Appropriate Testing	PBLI	Team	IM residents	Lab/imaging utilization report cards, paired with attending coaching
Given et al., 1981 ³⁷	Appropriate Testing	PBLI	Encounter provider	FM residents	Identification of trainee order patterns
Ryskina et al., 2014 ³⁸	Appropriate Treatment	PBLI	Encounter provider	IM residents	Prescription patterns for brand-name statins
Ryskina et al., 2015 ³⁹	Appropriate Treatment	PBLI	Ordering provider	IM residents	Prescription patterns for brand-name statins, influence of supervising attending practice
Rattanaumpawan et al., 2018 ⁴⁰	Appropriate Treatment	PBLI	Encounter provider	IM residents	Antibiotic orders for upper respiratory infections, and changing practice through feedback
Cerdeña et al., 2021 ⁴¹	Appropriate Treatment; Equity of Care	PBLI	Ordering provider	Psychiatry residents	Prescription pattern report cards by patient ethnoracial groups to address structural racism
Halverson et al., 2007 ⁴²	Appropriate Treatment	PBLI	Ordering provider	FM residents	Report cards for outpatient diabetes quality measures
Haynes et al., 2019 ⁴³	Appropriate Treatment	PBLI	EHR relationship	IM residents	Continuity clinic PBLI using EHR data and faculty coaching

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Bowdle et al., 2019 ⁴⁴	Patient Safety	PBLI	Unspecified	Anesthesiology residents	Bar code scanning behavior, with feedback to drive behavior change
Ehrenfeld et al., 2014 ⁴⁵	Patient Safety	PBLI	Unspecified	Anesthesiology residents	Perioperative metrics dashboard to provide automated, near-real-time feedback
Cho et al., 2015 ⁴⁶	Patient Safety	PBLI	Ordering provider	Residents (unspecified)	Resident alert behavior for outpatient medications
Cho et al., 2019 ⁴⁷	Patient Safety	PBLI	Ordering provider	Residents (unspecified)	Resident alert behavior for inpatient medications
Redwood et al., 2013 ⁴⁸	Patient Safety	PBLI	Ordering provider	Residents (unspecified)	Resident alert behavior, effect of feedback on behavior change
Agarwal et al., 2019 ⁴⁹	Medical Knowledge; Interpretative Accuracy	MK; PBLI	Report author	Radiology residents	EHR-measured interpretative accuracy and test scores, relationship with clinical volume
Surrey et al., 2013 ⁵⁰	Interpretative Accuracy	PBLI	Report author	Radiology residents	Interpretative accuracy via unstructured notes (character differences between resident and attending reports)
Xing et al., 2021 ⁵¹	Interpretative Accuracy	PBLI	Report author	Cytopathology fellows	EHR-measured interpretative accuracy, relationship with clinical volume
LaVine et al., 2020 ⁵²	Continuity of Care	SBP	Encounter provider	IM residents	Workflow intervention effect on continuity of care
Fortuna et al., 2016 ⁵³	Continuity of Care	SBP	Encounter provider	IM, FM, and pediatric residents	Continuity of care highly variable and is correlated with ambulatory quality measures
Lee et al., 2017 ⁵⁴	Continuity of Care	SBP	Encounter provider	FM residents	EHR-measured continuity of care paired with qualitative perceptions of ownership
Darden et al., 2001 ⁵⁵	Continuity of Care	SBP	Encounter provider	Pediatric residents	Continuity of care between residents and compared to post-training private practice
Garfunkel et al., 1998 ⁵⁶	Continuity of Care	SBP	Encounter provider	Pediatric residents	Continuity of care highly variable
Heist et al., 2014 ⁵⁷	Continuity of Care; Accountability to Patients	SBP; Professionalism	Encounter provider	IM residents	Schedule change effect on continuity of care and lab result follow-up
Litofsky et al., 2014 ⁵⁸	Continuity of Care	SBP	Note author; Encounter provider	Neurosurgery residents	Perioperative continuity of care
McBurney et al., 2004 ⁵⁹	Continuity of Care	SBP	Encounter provider	Pediatric residents	Continuity of care highly variable, relationship with time in clinic
Wajnberg et al., 2019 ⁶⁰	Continuity of Care	SBP	Encounter provider	IM residents	Empanelment intervention effect on continuity of care
Francis et al., 2009 ⁶¹	Continuity of Care	SBP	Encounter provider	IM residents	Continuity of care, relationship with time in clinic and panel size

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Wieland et al., 2013 ⁶²	Continuity of Care	SBP	Encounter provider	IM residents	Schedule change effect on continuity of care
Kronzer et al., 2021 ⁶³	Panel Size	SBP	Encounter provider	IM residents	Relationship between trainee demographics, panel size, and clinic slot fill
McCoy et al., 2013 ⁶⁴	Medical Knowledge	MK	Note author	IM and pediatric residents	Patient volume and in-training exam scores
Iglar et al., 2018 ⁶⁵	Medical Knowledge	MK	Encounter provider	FM residents	Outpatient visits and in-training exam scores
Hom et al., 2016 ⁶⁶	Work Patterns; Accountability to Patients	Professionalism; Other (CLE)	N/A	IM residents	Outpatient between-visit tasks while on inpatient rotations
McLean et al., 2008 ⁶⁷	Accountability to Patients	Professionalism	Team	GS and FM residents	EHR-measured direct review of patient images
Mosquera et al., 2021 ⁶⁸	Physician Well-Being	Professionalism	N/A	Psychiatry residents	EHR work patterns, and relationship with well-being
Was et al., 2016 ⁶⁹	Workload	Other (CLE)	Ordering provider, Note author	Pediatric interns	Workload on core inpatient rotations highly variable
Jacobsen et al., 2020 ⁷⁰	Work Patterns; Workload	Other (CLE)	Encounter provider	FM residents	Trainee outpatient between-visit workload is highly variable
Broussard et al., 2011 ⁷¹	Work Patterns	Other (CLE)	Encounter provider	Anesthesiology residents	Anesthesia preparation time, relationship with PGY
Verma et al., 2020 ⁷²	Work Patterns	Other (CLE)	N/A	IM residents	EHR work patterns, relationship with PGY, provider satisfaction, and patient satisfaction
Ouyang et al., 2016 ⁷³	Work Patterns	Other (CLE)	N/A	IM residents	EHR work patterns across time of day and day of week
Wang et al., 2019 ⁷⁴	Work Patterns	Other (CLE)	N/A	IM residents	EHR work patterns, relationship with year and rotation
Maloney et al., 2020 ⁷⁵	Work Patterns	Other (CLE)	N/A	GS, orthopedic, and OBGYN residents	Trainee EHR work patterns across specialties
Watson et al., 2020 ⁷⁶	Work Patterns	Other (CLE)	N/A	GS residents	Cumulative EHR time
Chen et al., 2016 ⁷⁷	Work Patterns	Other (CLE)	N/A	IM intern	EHR work patterns, changes from July to January
Goldszer et al., 2018 ⁷⁸	Work Patterns	Other (CLE)	N/A	EM, IM, and GS residents	EHR work patterns, changes from July to January
Cox et al., 2018 ⁷⁹	Work Patterns	Other (CLE)	N/A	GS residents	Cumulative EHR time
Dies et al., 2016 ⁸⁰	Work Patterns	Other (CLE)	N/A	GS residents	Physician assistant intervention, effect on EHR time
Anderson et al., 2020 ⁸¹	Work Patterns	Other (CLE)	Encounter provider	FM residents	EHR work patterns and after-hours use
Aziz et al., 2019 ⁸²	Work Patterns	Other (CLE)	N/A	VS residents	EHR work patterns and after-hours use

Author	Theme	Competency	Attribution method	Trainee	Synopsis
Holmgren et al., 2021 ⁸³	Work Patterns	Other (CLE)	N/A	Resident (unspecified)	Outpatient EHR work patterns and after-hours use, and changes over the academic year
Orenstein et al., 2018 ⁸⁴	Work Patterns	Other (CLE)	N/A	Pediatric residents	Simulation intervention to improve EHR tool usage
Shine et al., 2010 ⁸⁵	Work Hours	Other (CLE)	N/A	IM residents	Work hours, EHR-measured vs. self-reported
Gilleland et al., 2014 ⁸⁶	Work Hours	Other (CLE)	N/A	IM residents	Continuity clinic work hours, EHR-measured vs. self-reported
Ouyang et al., 2016 ⁸⁷	Work Hours	Other (CLE)	Team	IM residents	EHR-measured work hours and patient outcomes
Soleimani et al., 2021 ⁸⁸	Work Hours	Other (CLE)	N/A	IM residents	Inpatient work hours, EHR-measured vs. self-reported
Dziorny et al., 2019 ⁸⁹	Work Hours	Other (CLE)	N/A	Pediatric residents	Work hour violations, EHR-measured vs. self-reported
Dziorny et al., 2019 ⁹⁰	Work Hours	Other (CLE)	N/A	Pediatric residents	EHR-measured work hours, relationship with scheduled shifts
Lin et al., 2021 ⁹¹	Work Hours	Other (CLE)	Note structured data	GS residents	EHR-measured work hours for operative trainees