

Supplemental materials for:

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Supplementary Appendix 1

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1.1 Search protocol for “Impacts of Operational Failures on Primary Care Physicians’ work: A Critical Interpretive Synthesis of the literature”

Search terms used in following databases, from database inception until October 17th 2017:

A. PUBMED

B. CINAHL

C. EMBASE

D. PsycINFO

E. British Nursing Index

F. Health Business Elite

G. Healthcare Management Information Consortium (HMIC)

A. PUBMED

I = ambulatory care[title/abstract] OR general pract*[title/abstract] OR primary health care[title/abstract] OR primary care[title/abstract] OR family pract*[title/abstract] OR family medicine[title/abstract] OR family physician[title/abstract] OR “general practice” [MeSH Terms]

II = time-motion [title/abstract] OR (time[title/abstract] AND motion[title/abstract]) OR organizational efficiency[title/abstract] OR organisational efficiency [title/abstract] OR work*flow[title/abstract] OR “Task Performance and Analysis”[MeSH Terms] OR “Efficiency, Organizational” [MESH TERMS]

III = disrupt*[TITLE/ABSTRACT] OR interrupt*[TITLE/ABSTRACT] OR systems engineer*[TITLE/ABSTRACT] OR operational failure*[title/abstract] OR equipment failure* [TITLE/ABSTRACT] OR medical error* [TITLE/ABSTRACT] OR “medical errors” [MeSH Terms] OR “equipment failures” [MeSH Terms]

IV = I AND III

V: I AND II

VI: IV OR V

B. CINAHL

I = ((MM "primary health care")) OR ((MM "Family Practice")) OR ((MH "Physicians, Family")) OR (TI ("general pract* OR "primary health care" OR "primary care" OR "primary care physician* OR "family pract* or “family medicine” or “family physician* OR “ambulatory care”)) OR (AB ("general pract* OR "primary health care" OR "primary care" OR "primary care physician* OR "family pract* or “family medicine” or “family physician* OR “ambulatory care”))

II = ((MM " Task Performance and Analysis")) OR ((MM "Systems Analysis")) OR ((MH " Health Services Administration")) OR (TI ("time motion" OR "time AND motion" OR "time and motion stud* OR "organizational efficiency” OR "organisational efficiency” or “workflow”) OR (AB ("time motion" OR "time AND motion" OR "time and motion stud* OR "organizational efficiency” OR "organisational efficiency” or “workflow”))

III = ((MM " equipment failure")) OR (TI ("disrupt* OR "interrupt* OR "systems engineer* OR "operational failure* OR (AB ("disrupt* OR "interrupt* OR "systems engineer* OR "operational failure*)))

IV = I AND III

V = I AND II

VI = IV OR V

C. EMBASE

I (ambulatory care or general pract* or primary health care or primary care or family pract* or family medicine or family physician).ab. or (ambulatory care or general pract* or primary health care or primary care or family pract* or family medicine or family physician).ti. or (family practice or family physicians or general practice or general practitioners or primary health care or family medicine).sh.

II: (disrupt* or interrupt* or systems engineer* or operational failure* or equipment failure* or medical error* time-motion or (time and motion) or organizational efficiency or organisational efficiency or work*flow).ab. or (disrupt* or interrupt* or systems engineer* or operational failure* or equipment failure* or medical error* time-motion or (time and motion) or organizational efficiency or organisational efficiency or work*flow).ti.

or (efficiency, organizational or health services administration or task performance & analysis or task performance or patient care management).sh.

III = (time-motion or (time and motion) or organizational efficiency or organisational efficiency or work*flow).ab. or (time-motion or (time and motion) or organizational efficiency or organisational efficiency or work*flow).ti. or (equipment failure analysis or equipment failure or diagnostic errors or errors & omissions or medical error).sh.

IV = I and III

V= I AND II

VI= IV OR V

D. PsycINFO

I: ab("ambulatory care" or "general pract*" or "primary health care" or "primary care" or "family pract*" or "family medicine" or "family physician") OR ti("ambulatory care" or "general pract*" or "primary health care" or "primary care" or "family pract*" or "family medicine" or "family physician") OR su("family practice" OR "family physicians" OR "general practice" OR "general practitioners" OR "primary health care" OR "family medicine")

II: (ab("time-motion" OR (time AND motion) OR "organizational efficiency" OR "organisational efficiency" OR work*flow) OR ti("time-motion" OR (time AND motion) OR "organizational efficiency" OR "organisational efficiency" OR work*flow)) OR su("task performance and analysis" OR "efficiency, organizational" OR "health services administration" OR "patient care management" OR "systems analysis") OR cl("Organizational Behavior")

III = (ab("disrupt*" OR "interrupt*" OR "systems engineer*" OR "operational failure*" OR "equipment failure*" OR "medical error*") OR ti("disrupt*" OR "interrupt*" OR "systems engineer*" OR "operational failure*" OR "equipment failure*" OR "medical error*")) OR su("equipment failure analysis" OR "equipment failure" OR "diagnostic errors" OR "errors")

IV = I and III

V= I AND II

VI= IV OR V

E. British Nursing Index

I: (ti("ambulatory care" OR "general pract*" OR "primary health care" OR "primary care" OR "family pract*" OR "family medicine" OR "family physician") OR ab("ambulatory care" OR "general pract*" OR "primary health care" OR "primary care" OR "family pract*" OR "family medicine" OR "family physician")) OR su("primary health care professionals" OR "general practice" OR "general practitioners" OR "primary care" OR "primary health care" OR "general practice")

II: ab("time-motion" or (time and motion) or "organizational efficiency" or "organisational efficiency" or work*flow) OR ti("time-motion" or (time and motion) or "organizational efficiency" or "organisational efficiency" or work*flow) OR su("efficiency, organizational" OR "health services administration" OR "task performance & analysis" OR "task performance" OR "patient care management")

III = ab("disrupt*" OR "interrupt*" OR "systems engineer*" OR "operational failure*" OR "equipment failure*" OR "medical error*") OR ti("disrupt*" OR "interrupt*" OR "systems engineer*" OR "operational failure*" OR "equipment failure*" OR "medical error*") OR su("equipment failure analysis" OR "equipment failure" OR "diagnostic errors" OR "error analysis" OR "failure" OR "errors & omissions" OR "human error" OR "errors")

IV = I and III

V= I AND II

VI= IV OR V

F. Health Business Elite

I: AB ("ambulatory care" or "general pract*" or "primary health care" or "primary care" or "family pract*" or "family medicine" or "family physician") OR TI ("ambulatory care" or "general pract*" or "primary health care" or "primary care" or "family pract*" or "family medicine" or "family physician") OR SU (general practice or primary care)

II: TI ("time-motion" or (time and motion) or "organizational efficiency" or "organisational efficiency" or work*flow) OR AB ("time-motion" or (time and motion) or "organizational efficiency" or "organisational efficiency" or work*flow) OR SU ("Task Performance and Analysis" OR "Health Services Administration" OR "Patient Care Management")

III = AB ("disrupt*" OR "interrupt*" OR "systems engineer*" OR "operational failure*") OR TI ("disrupt*" OR "interrupt*" OR "systems engineer*" OR "operational failure*") OR SU ("equipment failure*" OR "medical error*")

IV = I and III

V= I AND II

VI= IV OR V

G. Healthcare Management Information Consortium (HMIC)

I: ("ambulatory care" OR "general pract*" OR "primary health care" OR "primary care" OR "family pract*" OR "family medicine" OR "family physician").ti,ab OR ("general practice" OR "primary care").sh

II. ("time-motion" OR (time AND motion) OR "organizational efficiency" OR "organisational efficiency" OR work*flow).ti,ab OR ("Task Performance and Analysis" OR "Health Services Administration" OR "Patient Care Management" OR "organizational efficiency" OR "Efficiency, Organizational").cl,sh

III. ("Task Performance and Analysis" OR "Health Services Administration" OR "Patient Care Management" OR "organizational efficiency" OR "Efficiency, Organizational").cl,sh

IV: ("disrupt*" OR "interrupt*" OR "systems engineer*" OR "operational failure*" OR "equipment failure*" OR "medical error*").ti,ab OR ("medical errors" OR "equipment failures").sh

V: I AND III

VI: I AND II

VII: V OR VI

Opengrey literature search using terms “operational failures” and “primary care”.

1.2 Table A1. Databases searched

Resource	Dates
EMBASE (via OVID)	1974 - Oct 2017
Cumulative Index to Nursing and Allied Health Literature with Full Text (via EBSCO)	1981 – Oct 2017
PsycINFO	1887 – Oct 2017
Medline (via Pubmed)	1946 – Oct 2017
British Nursing Index (via ProQuest)	1992- Oct 2017
Health Business Elite (via EBSCO)	1922- Oct 2017
Health Management Information Consortium (via Ovid)	1979- Oct 2017
Opengrey (via opengrey.eu)	1922 – Oct 2017

1.3 Table A2. Criteria used to judge quality of included papers

1. Are the aims and objectives of the research clearly stated?
 2. Is the research design clearly specified and appropriate for the aims and objectives of the research?
 3. Do the researchers provide a clear account of the process by which their findings were produced?
 4. Do the researchers display enough data to support their interpretations and conclusions?
 5. Is the method of analysis appropriate and adequately explicated?
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1.4 Table A3: data extraction template

Authors	
Year of publication	
Country	
Stated aim/objectives	
Qualitative or quantitative	
Study design	
Study setting	
Participants- profession	
Participants-number	
Key results (quantitative and qualitative)	
What operational failures identified or apparent in results	
Evidence of impact of operational failures on primary care professionals in this study	

1.5 Table A4. Studies included in review

First author, Year	Country	Aim (s)	Study design	Study setting and participants	Source of operational failure	Impact of operational failures on primary care physicians, evident in the included papers
Curry 2011 ¹	Canada	To examine if physicians incorporate decision-support technology into their clinical routines and follow clinical advice when provided	Quantitative: assessment of adherence to clinical guidelines for diagnostic imaging and acceptance of electronic decision support over 36 weeks	Primary care physicians (n= 15 – 19 at any one time) in a rural community family practice clinic	Computer decision support systems	Consumed time; disruption
Feldstein 2004 ²	US	To develop and evaluate medication safety alerts and processes for educating prescribers about the alerts	Qualitative: interviews	Primary care prescribers (n=20) in one group-model health maintenance organization	Computer decision support systems	Frustration; consumed time; cognitive burden
Gaikwad 2007 ³	Canada	To evaluate the accuracy of drug interaction alerts triggered by two electronic medical record systems in primary healthcare	Quantitative: modelling study of drug-drug interaction pairs in hypothetical patient scenarios	Modelling study of medication alerts triggered by two electronic medical record systems in primary healthcare	Computer decision support systems	Consumed time
Green 2015 ⁴	Canada	To evaluate the application of sound human factors engineering and cognitive science principles in designing a reminder system	Quantitative: retrospective cohort study	Five academically affiliated family medicine practices	Computer decision support systems	Disruption; consumed time

Hayward 2013 ⁵	UK	To understand how primary care physicians interact with prescribing computerised decision support systems	Mixed: quantitative and qualitative analysis of interactions between primary care physicians, patients, and computer systems using multi-channel video recordings	Consultations (n=112) with eight primary care physicians in three UK practices	Computer decision support systems	Disruption
Hysong 2010 ⁶	US	To evaluate how primary care physicians manage alerts related to critical diagnostic test results on their electronic medical record screens	Qualitative: interviews drawing on cognitive task analysis	Primary care physicians (n=28) in one large Veterans Affairs Medical Center	Computer decision support systems	Cognitive burden; required workarounds
Lapane 2008 ⁷	US	To describe primary care prescribers' perspectives on electronic prescribing drug alerts at the point of prescribing	Mixed: clinician surveys (web-based and paper) and focus groups with prescribers and staff	Prescribers and staff (n=157 for survey, n=276 for focus group) working in 64 practices using 1 of 6 e-prescribing technologies	Computer decision support systems	Frustration; consumed time
Maniam 2014 ⁸	US	To understand how physicians respond to computerised decision support alerts and understand their reasons for overriding alerts	Qualitative: interviews	Primary care physicians (n=23) with high inappropriate computerized decision support override rates	Computer decision support systems	Disruption; consumed time
Militello 2014 ⁹	US	To identify sources of variation in clinical workflow and implications for the design and implementation of electronic clinical decision support	Qualitative: rapid ethnographic observations of health care providers and support staff; focus groups and interviews with key informants.	Health care providers and support staff (n=205) and key informants (n=15) from eight Veterans Health Administration or academic medical centers regarded as leaders in developing and	Computer decision support systems	Requires additional tasks or workarounds; delays task completion; interfered with physician-patient relationship

				using clinical decision support		
Murphy 2012 ¹⁰	US	To categorize asynchronous alerts according to the information they conveyed and measure their impact on practitioner workload	Mixed: quantification, categorization and time-motion analysis of asynchronous alerts sent to primary care physicians	Primary care physicians (n=47) at a large, tertiary care Veterans Affairs facility over 4 evenly spaced 28-day periods	Computer decision support systems	Cognitive burden; requires additional tasks; delayed task completion
Richardson 2011 ¹¹	US	To elicit community-based physicians' current views on computer decision support and its desired capabilities	Qualitative: interviews and observations of primary care physicians	Primary care providers (n=30 interviews and n=25 observations) in 15 urban and rural community-based clinics using three different electronic health record systems	Computer decision support systems	Frustration; cognitive burden; consumed time
Russ 2009 ¹²	US	To assess barriers associated with the use of medication alerts	Qualitative: Direct observation of prescribing with inductive analysis of barriers associated with alerts	Prescribers (n=20) across five primary care clinics at a Veterans Affairs Medical Center	Computer decision support systems	Required additional tasks; consumed time; delayed decision-making
Russ 2012 ¹³	US	To uncover factors that influence the prescriber–alert interaction and identify strategies to improve alert design	Qualitative: field observations and interviews	Primary care physicians (n=30) in 5 Veterans Affairs Medical Centers	Computer decision support systems	Required additional tasks; consumed time; delayed decision-making
Saleem 2005 ¹⁴	US	To determine barriers and facilitators to the effective use of computerized clinical reminders	Qualitative: observations of staff interacting with computerized clinical	Primary care physicians (n=55) and nurses (35) in four geographically distributed Veterans	Computer decision support systems	Consumed time; cognitive burden

			reminders in primary care clinics	Administration medical centers		
Sittig 2006 ¹⁵	US	To explore potential factors affecting clinician acceptance of clinical decision support at the point of care	Quantitative: survey	Primary care physicians (n=110) within one group model Health Maintenance Organization	Computer decision support systems	Consumed time; cognitive burden
Vaziri 2009 ¹⁶	UK	To evaluate the experience of UK primary health care professionals using computer decision support systems	Mixed: synthesis of literature review, views from experts and stakeholders ascertained at a workshop and interviews	Attendees (n=30) at the Primary Health Care workshop of the British Computer Society healthcare computing conference	Computer decision support systems	Frustration; interfered with physician-patient relationship; cognitive burden
Weingart 2009 ¹⁷	US	To study respondents' satisfaction with e-prescribing systems, their perceptions of alerts, and their perceptions of behavior changes resulting from alerts	Quantitative: random sample survey	Ambulatory care clinicians (n=300) who used a commercial e-prescribing system	Computer decision support systems	Consumed time
Zazove 2017 ¹⁸	US	To explore how family medicine clinicians view, perceive, and use electronic clinical alerts	Qualitative: interviews drawing on cognitive task analysis	Primary care physicians (n=23) in two large primary care clinics	Computer decision support systems	Consumed time; cognitive burden; disruption
Agha 2014 ¹⁹	US	To describe associations between primary care clinicians' electronic health record use	Quantitative: time-motion study based on video and electronic health record activity capture	Primary care physicians (n=21) during primary care office visits (n=111) at four Veterans Administration medical Centers	Electronic health record	Consumed time; Interfered with physician-patient relationship

		patterns and usability, inefficiencies and burdensome workflow				
Al Alawi 2014 ²⁰	UAE	To explore physician satisfaction with an electronic medical records system	Qualitative: focus groups of 7-9 physicians	Primary care physicians (n=23) purposively sampled from practices	Electronic health record	Required additional tasks; consumed time
Baron 2005 ²¹	US	To describe the effects that use of electronic health records has had on practice finances, work flow, and office environment	Qualitative: case study and reflective account of practice's experience of implementing a new electronic health record system	A community-based general internal medicine practice with four physicians	Electronic health record	Disruption
Bouamrane 2013 ²²	UK	To elucidate General Practitioners' perspectives on their practice information systems	Qualitative: in-depth semi-structured interviews	Primary care physicians (n=25) invited from a list held by the NHS Scotland Information Services Division	Electronic health record	Consumed time; cognitive burden; interfered with physician-patient relationship
Christensen 2008 ²³	Norway	To study primary care physicians' use of electronic patient record systems, the time spent on using the records, and potential effects of these systems on the clinician-patient relationship	Mixed: focus groups, observations of primary care encounters, and a questionnaire survey	Focus groups of primary care physicians (n=23); observations in five practices using different record systems (n=11 primary care physicians in 80 encounters); a random selection of primary care members of the Norwegian Medical Association (n=408)	Electronic health record	Cognitive burden; required workarounds; consumed time; delayed task completion
Cutrona 2017 ²⁴	US	To assess electronic health record in-basket management	Mixed: audit and access log of electronic health record data and one focus group	Primary care providers (n=75 for audit, 5 participated in focus group) across a multisite healthcare system	Electronic health record	Consumed time; cognitive burden; dissatisfaction

Flanagan 2013 ²⁵	US	To examine both paper- and computer-based workarounds to the use of electronic health record systems	Qualitative: direct observations and opportunistic questions	Primary care providers and staff (n=120) working at eleven primary care clinics	Electronic health record	Required workarounds
Friedman 2014 ²⁶	US	To construct a typology of workarounds, including characteristics that distinguish benign or positive workarounds from those that are potentially harmful	Qualitative: comparative case study and ethnography	Seven clinician-owned primary care practices using five different electronic record systems	Electronic health record	Required workarounds; consumed time
Goldberg 2012 ²⁷	US	To understand the current use of electronic health records in small primary care practices	Qualitative: case study including interviews, observations and survey	6 primary care practice, including physicians and administrative staff (n= 38)	Electronic health record	Consumed time; disruption; interfered with physician-patient relationship
Halas 2015 ²⁸	US	To capture users' experiences with a newly implemented electronic medical record in family medicine academic teaching clinics	Qualitative: focus group discussions guided by semi structured questions	Three family medicine academic teaching clinics, including physicians (n=9), allied health faculty (n=11), and residents (n=8)	Electronic health record	Consumed time; disruption; interfered with physician-patient relationship; required workarounds
Hayward 2015 ²⁹	UK	To explore how information technology functions affected time allocation and styles of computer use during primary care physicians' consultations	Qualitative: Analysis of multichannel video recordings of between 12 and 18 10-min consultations	Recordings of 112 consultations with primary care physicians (n=6) purposively recruited from three diverse practices	Electronic health record	Consumed time; required workarounds

Howard 2013 ³⁰	US	To study the impact of electronic health record use on clinician and staff work burden	Qualitative: observations, interviews, photographic documentation	All staff and selected patients in seven small, community-based primary care practices	Electronic health record	Required additional tasks; consumed time
Koopman 2015 ³¹	US	To understand how physicians reviewed notes, their perceptions of the most and least important parts of those notes, and how the electronic health record display could be improved	Qualitative: cognitive task analysis with primary care physicians as they prepared for consultations	Primary care physicians (n=16) working in university-associated practices	Electronic health record	Consumed time; cognitive burden; frustration
Magrabi 2016 ³²	Australia	To examine the use of information technology in routine general practice by soliciting incidents involving problems with computer systems and associated peripheral devices	Quantitative: analysis of incident reports from primary care physicians with a focus on problems encountered by primary care physicians in using computers and other information technology in routine clinical work	Primary care physicians (n=87/4000) listed with the Australian Government's Department of Human Services	Electronic health record	Consumed time; disruption; frustration
McGeorge 2015 ³³	US	To identify activity changes due to the implementation of electronic health records with varying levels of interoperability	Qualitative: interviews and observations	Primary care physicians (n=16), administrative staff (n=26) and other clinical staff (n=11) at thirteen ambulatory care practices	Electronic health record	Required additional tasks; consumed time; interfered with physician-patient relationship

O'Malley 2015 ³⁴	US	To identify how electronic health records facilitate and pose challenges to primary care teams	Qualitative: interviews	63 participants including physicians to front-desk staff working in practices (n=27) recognized as patient-centered medical homes	Electronic health record	Required additional tasks
Samaan 2009 ³⁵	US	To assess the impact of electronic health record implementation and subsequent use on documentation, clinical processes, and patient access and flow	Quantitative: routine data analysis from one large clinic at baseline, 6 months and 2 years after electronic health record implementation	A large urban academic pediatric primary care health center	Electronic health record	Required additional tasks
Samoutis 2007 ³⁶	Cyprus	To evaluate implementation of an electronic medical record system	Mixed: qualitative interviews at 6 and 18 months after implementation of electronic medical record; quantitative questionnaire and electronic medical record usage parameters	All primary care physicians (n=5) and nurses (n=5) in one urban and one rural healthcare center	Electronic health record	Required additional tasks
Weir 2015 ³⁷	US	To explore perceptions on the availability and attributes of contextual information needed for clinical decision-making in electronic health records	Qualitative: interviews using cognitive task analyses and a modified critical incident technique	Primary care providers (n=17, 3 physicians) in a large Veterans Administration Medical Center with a fully implemented electronic record and a patient-centered medical home model of care	Electronic health record	Consumed time; cognitive burden

Crosson 2011 ³⁸	US	To identify successful implementation and techniques used for e-prescribing	Mixed: a comparative case study using observation and questionnaires	Five exemplar e-prescribing practices using different prescribing systems	E-prescribing systems	Required workarounds; consumed time
Crosson 2012 ³⁹	US	To evaluate the use of formularies and medication history information provided by two e-prescribing systems	Qualitative: comparative case study using interviews and observations 3 months after implementation of e-prescribing	Eight early adopter practices (1 to 4 physicians/practice), three months after implementation of stand-alone e-prescribing systems	E-prescribing systems	Required workarounds; consumed time
Devine 2010 ⁴⁰	US	To compare prescribing time between handwritten and electronic prescriptions using differing hardware configurations	Quantitative: direct observation, time-motion study	Prescribers (n=65) in three primary care clinics in a community-based health system	E-prescribing systems	Consumed time
Hollingworth 2007 ⁴¹	US	To compare prescribing times at three clinics that used paper-based prescribing, desktop, or laptop e-prescribing	Quantitative: time and motion	Prescribers (n=27) and other staff (n=42) at three clinics associated with a large healthcare provider	E-prescribing systems	Consumed time
Jariwala 2013 ⁴²	US	To describe the experience of primary care physicians with e-prescribing	Quantitative: internet based survey	Convenience sample of primary care physicians (n=443) registered on a physician panel maintained by a private research company	E-prescribing systems	Delayed task completion; required additional tasks; consumed time
Lapane 2011 ⁴³	US	To explore healthcare providers' opinions about the role of e-prescribing applications in improving efficiency	Mixed: survey and focus groups/ interviews	Focus groups of primary care physicians and office staff (n=276) from practices with at least 25% Medicare eligible patients and surveys of physicians (n=157)	E-prescribing systems	Consumed time

Lichtner 2013 ⁴⁴	UK	To assess the time-related changes conditioned by digital transmission of prescriptions specifically for repeat prescribing	Qualitative: field studies using interviews and observations	Primary care physicians (n=15), practice staff (n=26), and patients (n=12) in four of the first English practices to adopt e-prescribing	E-prescribing systems	Consumed time; required workarounds; cognitive burden;
Tamblyn 2006 ⁴⁵	Canada	To evaluate the acceptability and use of an integrated electronic prescribing and drug management system	Quantitative: audit trails, questionnaires, standardized tasks, and information from health insurance databases	Primary care physicians (n=28) working in full-time fee-for-service practice in a large metropolitan area	E-prescribing systems	Consumed time; required workarounds
Weingart 2009 ⁴⁶	US	To understand the reasons for adoption and use of e-prescribing, clinicians' complaints and perceived benefits of drug allergy and interaction alerts	Qualitative: focus groups (n=3) on use and value of e-prescribing and medication safety alerts	Primary care physicians (n=25) from a list held by a large insurance provider	E-prescribing systems	Delayed task completion; required additional tasks
Cohen 2016 ⁴⁷	US	To determine the perceived barriers to meeting the meaningful use care coordination criteria	Quantitative: survey of primary care practices	Random sample of 328 state-wide practices stratified by practice size	E-referral systems	Delayed task completion; required additional tasks; consumed time
Kim 2009 ⁴⁸	US	To assess the impact of electronic referrals on workflow and clinical care	Quantitative: 18-item, web-based questionnaire	All primary care physicians (n=368) who had the option of referring to San Francisco General Hospital	E-referral systems	Consumed time; delayed task completion
Vimalananda 2015 ⁴⁹	US	To systematically review and summarize the literature describing the use and effects of e-consults	Review: Narrative synthesis	27 papers including 22 research studies and five system descriptions	E-referral systems	Required additional tasks; consumed time

Armor 2016 ⁵⁰	US	To evaluate medication discrepancies between hospital discharge and primary care follow-up	Quantitative: retrospective study of medication discrepancies and adverse events	Review of patients (n=43) attending on academic family medicine outpatient clinic.	Information: medication discrepancies	Consumed time
Redmond 2016 ⁵¹	Ireland	To survey primary care physicians and community pharmacists on medication reconciliation as patients transition in care	Quantitative: Survey which included free text responses, analyzed by data-driven content analysis	Primary care physicians (n=2364), physicians in training (n=311) and community pharmacists (n=2382) invited from lists held on national registers	Information: medication discrepancies	Frustration
Sellappans 2015 ⁵²	Malaysia	To identify the challenges faced by primary care physicians when prescribing medications for patients with chronic diseases	Qualitative: focus groups	Family medicine trainees (n=14) and service medical officers (n=5) affiliated with a teaching primary care clinic	Information: medication discrepancies	Frustration
Vuong 2017 ⁵³	Canada	To evaluate an intervention to improve the quality of admission medication reconciliation in LTC homes and retirement homes	Quantitative: Plan-Do-Study-Act (PDSA) of an iterative intervention tracking medication-reconciliation quality scores	One inpatient health center, a senior living unit, care home, and pharmacy provider	Information: medication discrepancies	Consumed time
Hickner 2008 ⁵⁴	US	To describe types, predictors and outcomes of testing errors reported by family physicians and office staff	Quantitative: analysis of anonymous reports of errors related to the testing process, which staff recognized or experienced during the course of their work day	Primary care physicians and office staff (n=243) at a maximum variation sample of eight practices	Information: test results	Delayed decision-making; consumed time

Poon 2004 ⁵⁵	US	To identify problems in current test result management systems and possible ways to improve these systems	Quantitative: survey	Physicians (n=262) working in 15 practices affiliated with two large urban teaching hospitals	Information: test results	Dissatisfaction
Groene 2012 ⁵⁶	Spain	To explore handover practices at discharge	Qualitative: interviews with thematic analysis	Primary care physicians (n=7), primary care nurses (4), patients (n=12), and hospital staff (11) at two hospitals and associated primary care centers	Information: continuity	Delayed decision-making; Interfered with physician-patient relationship
Jones 2014 ⁵⁷	US	To understand the challenges in coordination of care from the perspective of hospitalists and primary care physicians	Qualitative: focus groups	Purposive sample of primary care providers (n = 24), and hospital physicians (n=60) participating in collaboratives to improve care transitions	Information: continuity	Required additional tasks; delayed decision-making
Kljakovic 2004 ⁵⁸	New Zealand	To describe the transfer of patient information from hospital to general practice	Quantitative: analysis and comparison of discharge/ outpatient letters and electronic health records in hospital and general practice	Discharge and outpatient letters for patients registered with primary care physicians (n=12) working in two computerized general practices	Information: continuity	Delayed decision-making
Kripalani 2007 ⁵⁹	US	To characterize the types and prevalence of deficits in information transfer between hospital-based physicians and primary care physicians at hospital discharge	Review: Systematic review	Observational (n = 55) and intervention (n = 18) studies investigating communication and information transfer at hospital discharge	Information: continuity	Delayed decision-making; dissatisfaction

Mastellos 2014 ⁶⁰	UK	To explore the range, quality and sophistication of existing information systems in primary care to capture what is needed to provide a safe service	Mixed: semi-structured interviews and survey evaluating primary care physicians' experience with information systems	Primary care physicians (n=25) purposively sampled from 15 practices in an Integrated Care Pilot	Information: continuity	Delayed decision-making
O'Malley 2009 ⁶¹	US	To identify current best practices in coordination, challenges and lessons learned	Qualitative: in-depth interviews of physicians and national experts	Primary care physicians (n=62) associated with the American College of Physicians and the American Academy of Family Practice	Information: continuity	Required workarounds
Smith 2005 ⁶²	US	To describe primary care clinicians' reports of missing clinical information	Quantitative: cross-sectional survey	Primary care physicians (n=253) surveyed about patient visits (n=1614) at 32 practices in a "Improving Patient Safety" consortium	Information: continuity	Consumed time; required additional tasks; delayed decision-making
Matthews- King 2016 ⁶³	UK	To reveal the administrative challenges primary care physicians face in England	Quantitative: survey	500 primary care physicians and practice managers	Materials and supplies	Disruptions
Varkey 2009 ⁶⁴	US	To determine differences in workplace organizational characteristics, among clinics serving various proportions of minority patients	Quantitative: secondary analysis of data from the observational Minimizing Error Maximizing Outcome (MEMO) study	Surveys of clinic managers (n=96), primary care physicians (n=388), and adult patients (n=1701) from 96 primary care clinics	Materials and supplies	Disruptions
Varkey 2013 ⁶⁵	US	To assess associations between the work environment, errors and quality among clinics serving various	Quantitative: secondary analysis of chart audit data from the observational Minimizing Error	Primary care physicians (n=287) and patients (n=1207) in 73 clinics with >=30% minority patients	Materials and supplies	Disruptions

		proportions of minority patients	Maximizing Outcome (MEMO) study	versus <30% minority patients		
Hoonakker 2017 ⁶⁶	US	To examine the impact of secure messaging on workflow of clinicians, staff and patients	Mixed: case study design with observation, interviews and survey	Physicians (n=39 interviews /observations, n=43 surveys) and other staff (n=13 interviews /observations, n=15 surveys) in five urban practices	Practice organization: systems to support interaction with patients	Consumed time; requires additional tasks and workarounds
Kravitz 2000 ⁶⁷	US	To determine the association of limited English proficiency with visit time, health care resource utilization, and adherence to follow-up	Quantitative: time-motion study with quantitative analysis	Patient consultations (n=285) at three clinics where 10-15% of registered patients require interpretive assistance	Practice organization: systems to support interaction with patients	Consumed time; Interfered with physician-patient relationship
Ozkaynak 2014 ⁶⁸	US	To explore secure messaging implementation at two Veterans Health Administration facilities	Qualitative: semi-structured interviews	Primary care providers (n=29) in eight primary care teams	Practice organization: systems to support interaction with patients	Consumed time; requires additional tasks
Baron 2010 ⁶⁹	US	To count units of primary care work including non-patient visit work during the course of a year	Qualitative: case study	Primary care physicians (n=5) at a community-based practice	Practice organization	Required additional tasks and workarounds
Best 2006 ⁷⁰	US	To identify overlap in task performance among multiple primary care occupational groups	Mixed: qualitative focus groups and quantitative survey data collection	Representatives of each primary care worker from six practices manifesting diverse organizational characteristics	Practice organization	Required additional tasks; consumed time

Brazil 2010 ⁷¹	US	To examine the relationship of organizational culture on provider job satisfaction and perceived clinical effectiveness in primary care pediatric practices	Quantitative: cross-sectional, secondary analysis of trial data that compared practitioner-versus organization-focused interventions designed to enhance guideline implementation	Physicians (n=127) and non-clinicians (n=247) in 36 primary care pediatric practices	Practice organization	Dissatisfaction
Chesluk 2010 ⁷²	US	To examine how the entire primary care practice team works together in the course of caring for patients	Qualitative: ethnography	Three primary care practices representing different practice types	Practice organization	Required additional work; consumed time; dissatisfaction
Chisholm 2001 ⁷³	US	To determine the number of interruptions and characterize tasks performed in emergency departments versus primary care offices	Quantitative: time-motion task-analysis: single observer followed participants and recorded tasks in 1-minute increments	Primary care (n=22) and emergency physicians (n=22) from 22 primary care offices and 5 community hospitals	Practice organization	Interruptions; dissatisfaction
Crabtree 2011 ⁷⁴	US	To understand organizational change in primary care practices emphasizing a complexity science perspective	Mixed: narrative review of multimethod observational and intervention studies that informed each other in an emergent design	Over 350 primary care practices	Practice organization	Frustration; requires additional tasks
Dearden 1996 ⁷⁵	UK	To discover the patients' view of interruptions	Quantitative: primary care physician recorded interruptions of own consultations	Consultations (n=619) at one urban general practice	Practice organization	Interruptions; interfered with physician-patient relationship

Elmore 2016 ⁷⁶	UK	To examine the relationship between consultation length and patient-reported communication, trust and confidence in the doctor	Qualitative: video-recordings of face-to-face consultations	Consultations (n=440) with primary care physicians (n=45) in thirteen purposively sampled practices	Practice organization	Interruptions; interfered with physician-patient relationship
Herring 2009 ⁷⁷	UK	To test an organizational improvement approach in a general practice setting	Qualitative: case study	Three general practices recruited by the National Health Service	Practice organization	Consumed time; delayed decision-making
Holman 2016 ⁷⁸	US	To evaluate the workflow of physician tasks that occur during face-to-face consultations	Mixed: direct observation of the entire patient visit; task-level recording; post-observation primary care physician interview	Primary care physicians (n=10) from ten randomly chosen clinics	Practice organization and electronic health record	Requires additional tasks and workarounds; consumed time
Hung 2017 ⁷⁹	US	To examine a wide range of performance outcomes after implementation of Lean methodology	Quantitative: stepped wedge design with analysis of workflow, productivity, costs, clinical quality, and satisfaction	Primary care physicians (n=328) in 46 primary care departments in an ambulatory care delivery system	Practice organization	Consumed time; dissatisfaction
James 2015 ⁸⁰	US	To better understand the sources of and remedies for non-clinical inefficiency in primary care	Mixed: practice information surveys, practice process mapping guides and observations	5 practices from research network and 8 practices in a medical management association	Practice organization	Frustration; required additional tasks
Koong 2015 ⁸¹	Singapore	To understand the impact of unplanned phone calls during primary health care consultations	Qualitative: focus groups with patients and healthcare workers (n=16)	Physicians, nurses and pharmacists (n=16) and patients (n=15) at one public primary healthcare institution	Practice organization	Interruptions; frustration

Kumarapeli 2013 ⁸²	UK	To explore the context and use of electronic record systems to provide insights into improving their use in clinical practice	Qualitative: multi-channel visual study of the consultation room and coded interactions between clinician, patient, and computer	Consultations (n=163) with primary care physicians (n=16) in eleven general practice surgeries	Practice organization	Interruptions
Linzer 2009 ⁸³	US	To assess the relationship among adverse primary care work conditions, adverse physician reactions and patient care.	Quantitative: surveys and chart audits measuring physician perception of clinic workflow, work control, organizational culture, physician satisfaction, stress, burnout, intent to leave practice, health care quality and errors	Primary care physicians (n=422) and adult patients (n=1795) at 119 diverse ambulatory clinics	Practice organization	Dissatisfaction
Linzer 2015 ⁸⁴	US	To assess if improvements in work conditions improve clinician stress and burnout	Quantitative: cluster randomized controlled trial	Primary care physicians (n=135) at 34 diverse clinics	Practice organization	Dissatisfaction
Linzer 2017 ⁸⁵	US	To better understand how clinicians' job satisfaction relates to work conditions and outcomes for clinicians and patients	Quantitative: secondary analysis of data from a cluster randomized trial	Primary care physicians (n=146) and advanced practice providers (n=22) in 34 diverse clinics	Practice organization	Dissatisfaction
O'Connor 2007 ⁸⁶	Ireland	To determine the frequency and source of consultation interruption	Quantitative: two medical observers recorded all interruptions during consultations on a paper data sheet	Primary care physicians (n=20) randomly selected from lists of all physicians practicing in the city	Practice organization	Interruptions

Paxton 1996 ⁸⁷	UK	To compare the rate and perceptions of interruptions experienced by practice nurses and primary care physicians	Quantitative: self-recording of information on all surgery consultations on one day in every 15 over one year	Primary care physicians (n=85) representing a cross-section of single-handed doctors and those working in group practices	Practice organization	Interruptions
Peleg 2000 ⁸⁸	Israel	To characterize interruptions to the patient-physician encounter	Quantitative: primary care physicians self-recorded interruptions of consultations	Primary care physicians (n=4) in one clinic	Practice organization	Interruptions
Perez 2017 ⁸⁹	US	To determine how chaos in the clinic was associated with work conditions and quality of care measures	Quantitative: secondary analysis of surveys and chart audits in the Minimizing Error, Maximizing Outcome (MEMO) study	Primary care physicians (n=413) and patients (n=1751) at 112 diverse clinics	Practice organization	Dissatisfaction
Rhoades 2001 ⁹⁰	US	To examine physician-patient communication patterns and interruptions during consultations	Quantitative: analysis of interruptions observed during 60 routine primary care office consultations	Routine consultations (n=60) by a convenience sample of patients (n=22) at a primary care teaching clinic	Practice organization	Interruptions
Shipman 2013 ⁹¹	US	To demonstrate the potential of reducing waste and inefficiency	Review: narrative evidence review	Review of the evidence of time-consuming, inefficient activities that can diminish the capacity of the primary care workforce	Practice organization	Consumed time; required additional tasks
Shvartzman 1992 ⁹²	Israel	To determine the number and nature of interruptions to consultations	Quantitative: observation of consultations with counting of interruptions	Primary care physicians (n=4) in one neighborhood health center	Practice organization	Interruptions

Sinnott 2013 ⁹³	Ireland	To review primary care physicians' perceptions on the clinical management of multimorbidity	Qualitative: Meta-ethnography	Systematic review of ten qualitative studies that explored physicians' experiences of clinical management of multimorbidity	Practice organization	Required additional tasks
Sinsky 2013 ⁹⁴	US	To highlight primary care innovations gathered from high-functioning primary care practices	Qualitative: Observations and interviews	23 high-performing primary care practices in the US	Practice organization	Dissatisfaction
Stroebe 2005 ⁹⁵	US	To describe an improvement process based on the understanding primary care practices as complex adaptive systems	Qualitative: Case study	One two-physician and one-nurse practice in the North East US	Practice organization	Consumed time

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