

Appendix A. Search Strategies

**Database: Ovid MEDLINE(R) and Ovid OLDMEDLINE(R)
<1990 to April Week 5 2014>**

Search Strategy:

-
- 1 (health information adj5 exchange\$.mp.
 - 2 hie.mp.
 - 3 exp Medical Records/
 - 4 exp Systems Analysis/
 - 5 exp Medical Informatics/
 - 6 Information Dissemination/
 - 7 3 or 4 or 5 or 6
 - 8 2 and 7
 - 9 1 or 8
 - 10 health information organization\$.mp.
 - 11 7 and 10
 - 12 (hio or hios or rhio or rhios).mp.
 - 13 7 and 12
 - 14 ((clinical\$ or health\$) adj5 (data adj3 exchange\$)).mp.
 - 15 7 and 14
 - 16 (patient\$ adj2 match\$.mp.
 - 17 7 and 16
 - 18 ((query or querie\$) adj3 (base or based or bases or basing) adj5 exchange\$.mp.
 - 19 7 and 18
 - 20 directed exchange\$.mp.
 - 21 7 and 20
 - 22 ((consumer\$ or patient\$) adj5 mediat\$ adj7 exchange\$.mp.
 - 23 7 and 22
 - 24 ((health information adj5 tech\$) and exchange\$.mp.
 - 25 7 and 24
 - 26 (health information adj7 network\$.mp.
 - 27 7 and 26
 - 28 ((health information or ((electronic\$ or computer\$) adj2 (health or medic\$ or patient\$) adj2 record\$) or ehr or emr) adj7 exchange\$.mp.
 - 29 7 and 28
 - 30 (exchange\$ adj5 network\$.mp.
 - 31 7 and 30 (116)
 - 32 (interoperab\$ adj7 standard\$.mp. (320)

- 33 7 and 32
- 34 ((inter or between or across) adj3 (organization\$ or systems) adj7 network\$).mp.
- 35 7 and 34
- 36 9 or 11 or 13 or 15 or 17 or 19 or 21 or 23 or 25 or 27 or 29 or 31 or 33 or 35
- 37 Medical Record Linkage/
- 38 exp systems integration/
- 39 37 and 38
- 40 exp Cooperative Behavior/
- 41 37 and 40
- 42 exp Medical Informatics Applications/
- 43 37 and 42
- 44 10 or 12 or 14 or 16 or 18 or 20 or 22 or 24 or 26 or 28 or 30 or 32
- 45 43 and 44
- 46 36 or 39 or 41 or 45
- 47 6 and 38 and 42
- 48 6 and 38 and 40
- 49 4 and 37 and 40
- 50 4 and 37 and 42
- 51 6 and 37 and 42
- 52 6 and 37 and 40
- 53 4 and 38 and 40
- 54 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53
- 55 limit 54 to english language

Database: PsycINFO <1990 to June Week 1 2014>

Search Strategy:

-
- 1 ((healthcare information or health information) adj5 exchange\$).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures]
 - 2 exp medical records/
 - 3 exp information systems/
 - 4 exp Information Dissemination/
 - 5 exp systems analysis/
 - 6 exp information technology/
 - 7 exp computer mediated communication/
 - 8 2 or 3 or 4 or 5 or 6 or 7
 - 9 hie.mp.
 - 10 8 and 9
 - 11 1 or 10
 - 12 health information organization\$.mp.

- 13 (hio or hios or rhio or rhios).mp.
- 14 ((clinical\$ or health\$) adj5 (data adj3 exchange\$)).mp.
- 15 (patient\$ adj2 match\$).mp.
- 16 8 and 15
- 17 ((query or querie\$) adj3 (base or based or bases or basing) adj5 exchange\$).mp.
- 18 directed exchange\$.mp.
- 19 ((consumer\$ or patient\$) adj5 mediat\$ adj7 exchange\$).mp.
- 20 ((health information adj5 tech\$) and exchange\$).mp.
- 21 (health information adj7 network\$).mp.
- 22 ((health information or ((electronic\$ or computer\$) adj2 (health or medic\$ or patient\$) adj2 record\$) or ehr or emr) adj7 exchange\$).mp.
- 23 (exchange\$ adj5 network\$).mp.
- 24 8 and 23
- 25 (interoperab\$ adj7 standard\$).mp.
- 26 11 or 12 or 14 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 24 or 25

Database: EBM Reviews - Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, Database of Abstracts of Reviews of Effects, NHS Economic Evaluation Database <1990 to 2nd Quarter of 2014>

Search Strategy:

- 1 (health information adj5 exchange\$.mp.
- 2 hie.mp.
- 3 ((health or medical) adj3 (record or records)).mp. [mp=title, text, subject heading word]
- 4 ((System or systems) adj3 Analysis).mp. [mp=title, text, subject heading word]
- 5 ((health\$ or medic\$) adj5 informatic\$.mp. [mp=title, text, subject heading word]
- 6 ((informat\$ or data) adj5 (link\$ or disseminat\$ or transfer\$ or request\$ or share\$ or sharing)).mp. [mp=title, text, subject heading word]
- 7 3 or 4 or 5 or 6
- 8 2 and 7
- 9 1 or 8
- 10 health information organization\$.mp.
- 11 7 and 10
- 12 (hio or hios or rhio or rhios).mp.
- 13 7 and 12
- 14 ((clinical\$ or health\$) adj5 (data adj3 exchange\$)).mp.
- 15 7 and 14
- 16 (patient\$ adj2 match\$.mp.
- 17 7 and 16
- 18 ((query or querie\$) adj3 (base or based or bases or basing) adj5 exchange\$.mp.
- 19 7 and 18
- 20 directed exchange\$.mp.
- 21 7 and 20
- 22 ((consumer\$ or patient\$) adj5 mediat\$ adj7 exchange\$.mp.
- 23 7 and 22
- 24 ((health information adj5 tech\$) and exchange\$.mp.
- 25 7 and 24
- 26 (health information adj7 network\$.mp.
- 27 7 and 26
- 28 ((health information or ((electronic\$ or computer\$) adj2 (health or medic\$ or patient\$) adj2 record\$) or ehr or emr) adj7 exchange\$.mp.
- 29 7 and 28
- 30 (exchange\$ adj5 network\$.mp.
- 31 7 and 30

- 32 (interoperab\$ adj7 standard\$.mp.
- 33 7 and 32
- 34 ((inter or between or across) adj3 (organization\$ or systems) adj7 network\$.mp.
- 35 7 and 34
- 36 ((health\$ or medic\$) adj3 record adj7 (link\$ or disseminat\$ or transfer\$ or request\$ or share\$ or sharing)).mp. [mp=title, text, subject heading word]
- 37 9 or 11 or 13 or 15 or 17 or 19 or 21 or 23 or 25 or 27 or 29 or 31 or 33 or 35 or 36

Appendix B. Inclusion and Exclusion Criteria

Table B1. Inclusion and Exclusion Criteria

	Include	Exclude
Population	<u>All KQs</u> : Any individual or group of health care providers, patients, managers, health care institutions, or regional organizations.	<u>All KQs</u> : Not applicable to a U.S. population.
Interventions	<u>All KQs</u> : Health Information Exchange . HIE is defined as the electronic sharing of clinical information among users such as health care providers, patients, administrators or policy makers across the boundaries of health care institutions, health data repositories, States and others, typically not within a single organization or among affiliated providers, while protecting the integrity, privacy, and security of the information.	<u>All KQs</u> : Hypothetical HIEs, HIE within an organization/single setting, independent electronic prescription or referral system, a single person accessing multiple systems, registries, HIE for research, marketing or administration, non-electronic transfers.
Comparators	<u>KQ 1-3</u> : Time period prior to HIE implementations, geographic or organizational locations without HIE, situations in which HIE is not available, multiple types of HIE, characteristics of the different settings and systems in which HIE is used. <u>KQ 4-8</u> : No comparison required	<u>KQ 1-3</u> : No comparator <u>KQ 4-8</u> : None

Abbreviations: HIE= health information exchange; KQ = key question; U.S. = United States.

Appendix C. List of Included Studies

Abramson EL, McGinnis S, Edwards A, et al. Electronic health record adoption and health information exchange among hospitals in New York State. *J Eval Clin Pract.* 2012;18(6):1156-62. PMID: 21914089.

Abramson EL, McGinnis S, Moore J, et al. A statewide assessment of electronic health record adoption and health information exchange among nursing homes. *Health Serv Res.* 2014;49(1 Pt 2):361-72. PMID: 24359612.

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Adler-Milstein J, Bates DW, Jha AK. A survey of health information exchange organizations in the United States: implications for meaningful use. *Ann Intern Med.* 2011;154(10):666-71. PMID: 21576534.

Adler-Milstein J, Bates DW, Jha AK. Operational health information exchanges show substantial growth, but long-term funding remains a concern. *Health Aff (Millwood).* 2013;32(8):1486-92. PMID: 23840051.

Adler-Milstein J, DesRoches CM, Jha AK. Health information exchange among US hospitals. *Am J Manag Care.* 2011;17(11):761-8. PMID: 22084896.

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Ben-Assuli O, Shabtai I, Leshno M. The impact of EHR and HIE on reducing avoidable admissions: controlling main differential diagnoses. *BMC Med Inform Decis Mak.* 2013;13:49. PMID: 23594488.

Bouhaddou O, Bennett J, Cromwell T, et al. The Department of Veterans Affairs, Department of Defense, and Kaiser Permanente Nationwide Health Information Network exchange in San Diego: patient selection, consent, and identity matching. *AMIA Annu Symp Proc.* 2011;2011:135-43. PMID: 22195064.

Byrne CM, Mercincavage LM, Bouhaddou O, et al. The Department of Veterans Affairs' (VA) implementation of the Virtual Lifetime Electronic Record (VLER): Findings and lessons learned from Health Information Exchange at 12 sites. *Int J Med Inf.* 2014;83(8):537-47. PMID: 24845146.

Campion TR, Jr., Ancker JS, Edwards AM, et al. Push and pull: physician usage of and satisfaction with health information exchange. *AMIA Annu Symp Proc.* 2012;2012:77-84. PMID: 23304275.

Campion TR, Jr., Edwards AM, Johnson SB, et al. Health information exchange system usage patterns in three communities: practice sites, users, patients, and data. *Int J Med Inf.* 2013;82(9):810-20. PMID: 23743323.

Campion TR, Jr., Vest JR, Ancker JS, et al. Patient encounters and care transitions in one community supported by automated query-based health information exchange. *AMIA Annu Symp Proc.* 2013;2013:175-84. PMID: 24551330.

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Tzeel A, Lawnicki V, Pemble KR. "Hidden" Value: How Indirect Benefits of Health Information Exchange Further Promote Sustainability. *Am Health Drug Benefits*. 2012;5(6):333-40. PMID: 24991331.

Unertl KM, Johnson KB, Lorenzi NM. Health information exchange technology on the front lines of healthcare: workflow factors and patterns of use. *J Am Med Inform Assoc*. 2012;19(3):392-400. PMID: 22003156.

Unertl MK, Johnson BK, Gadd SC, et al. Bridging Organizational Divides in Health Care: An Ecological View of Health Information Exchange. *JMIR Med Inform*. 2013;1(1):e3.

Vest JR. Health information exchange and healthcare utilization. *J Med Syst.* 2009;33(3):223-31. PMID: 19408456.

Vest JR. More than just a question of technology: factors related to hospitals' adoption and implementation of health information exchange. *Int J Med Inf.* 2010;79(12):797-806. PMID: 20889370.

Vest JR, Gamm LD, Ohsfeldt RL, et al. Factors associated with health information exchange system usage in a safety-net ambulatory care clinic setting. *J Med Syst.* 2012;36(4):2455-61. PMID: 21523428.

Vest JR, Grinspan ZM, Kern LM, et al. Using a health information exchange system for imaging information: patterns and predictors. *AMIA Annu Symp Proc.* 2013;2013:1402-11. PMID: 24551416.

Vest JR, Jasperson JS. How are health professionals using health information exchange systems? Measuring usage for evaluation and system improvement. *J Med Syst.* 2012;36(5):3195-204. PMID: 22127521.

Vest JR, Jasperson JS, Zhao H, et al. Use of a health information exchange system in the emergency care of children. *BMC Med Inform Decis Mak.* 2011;11:78. PMID: 22208182.

Vest JR, Kern LM, Champion TR, Jr., et al. Association between use of a health information exchange system and hospital admissions. *Appl Clin Inform.* 2014;5(1):219-31. PMID: 24734135.

Vest JR, Kern LM, Silver MD, et al. The potential for community-based health information exchange systems to reduce hospital readmissions. *J Am Med Inform Assoc.* 2014 PMID: 25100447.

Vest JR, Miller TR. The association between health information exchange and measures of patient satisfaction. *Appl Clin Inform.* 2011;2(4):447-59. PMID: 23616887.

Vest JR, Zhao H, Jasperson J, et al. Factors motivating and affecting health information exchange usage. *J Am Med Inform Assoc.* 2011;18(2):143-9. PMID: 21262919.

Willis JM, Edwards R, Anstrom KJ, et al. Decision support for evidence-based pharmacotherapy detects adherence problems but does not impact medication use. *Stud Health Technol Inform.* 2013;183:116-25. PMID: 23388267.

Appendix D. List of Excluded Studies

By the numbers. States with the most health information exchanges. Based on eHealth initiative's directory of health information exchange initiatives. Mod Healthc. 2010;40(14):34. PMID: 20402215

Exclusion: Wrong study design

By The Numbers: States with the most health information exchanges. Mod Healthc. 2011;41(21):32.

Exclusion: Wrong study design

Connecting communities: making inroads to exchange electronic healthcare data at the local level. Qual Lett Healthc Lead. 2005;17(8):2-10. PMID: 16304880

Exclusion: Wrong study design

Electronic tools for health information exchange: An evidence-based analysis. Ont Health Technol Assess Ser. 2013;13(11):1-76. PMID: 2419479

Exclusion: Systematic review not meeting our requirements

Findings from site visit to community clinic health network in san Diego, CA. Available at: <http://aspe.hhs.gov/sp/reports/2010/chcit2010/SanDiego.html>. Accessed November 10, 2014.

Exclusion: Wrong study design

Health information exchange activities continuing to mature, says survey. Healthc Financ Manage. 2007;61(2):11.

Exclusion: Wrong study design

Health Information Exchange May Reduce Hospital Admissions. For the Record (Great Valley Publishing Company, Inc). 2014;26(5):32.

Exclusion: Wrong study design

High-tech approach to medication reconciliation saves time, bolsters safety at hospital in northern Virginia. ED Manag. 2011;23(10):117-9. PMID: 21972757

Exclusion: Not HIE

Implementation of SNOMED-CT needed to facilitate interoperable exchange of health information. J AHIMA. 2005;76(9):30, 2.

Exclusion: Wrong study design

Information exchange yields better decisions. ED Manag. 2010;22(9):103-4. PMID: 20853581

Exclusion: No data relevant to a Key Question

New computer network helps EDs to reduce redundant test orders: observers see significant savings, benefits in patient safety. *ED Manag.* 2008;20(12):133-4. PMID: 19086738

Exclusion: Wrong study design

Physicians support health information exchange but are concerned about paying monthly fees. *AHRQ Research Activities.* 2010(359):14.

Exclusion: Wrong study design

A primer for building RHIOs. *Hosp Health Netw.* 2006;80(2):49-56. PMID: 16572948

Exclusion: Wrong study design

Social Security report details \$2 million return on HIE. *For the Record* (Great Valley Publishing Company, Inc). 2010;22(4):6.

Exclusion: Wrong study design

States with the most health information exchanges. *Mod Healthc.* 2009;39(27):32. PMID: 19606671

Exclusion: Wrong study design

States with the most health information exchanges. Based on ehealth initiative's map of health information exchange activity in the U.S. *Mod Healthc.* 2011;41(21):32. PMID: 21714447

Exclusion: Wrong study design

States with the most health information exchanges: Based on eHealth initiative's map of health information exchange activity in the U.S. *Mod Healthc.* 2012;42(24):34. PMID: 22957359

Exclusion: Wrong study design

Study: More Hospitals Joining Health Information Exchanges. *J AHIMA.* 2012;83(11):13.

Exclusion: Wrong study design

Survey shows health information exchange on the rise. *For the Record* (Great Valley Publishing Company, Inc). 2011;23(15):5.

Exclusion: Wrong study design

Wisconsin HIE optimizes community care. Communication among ED clinicians and federally qualified health centers in the Milwaukee area was improved, including real-time access to patient historical-encounter data. *Health Manag Technol.* 2009;30(12):28-9. PMID: 20043491

Exclusion: Wrong study design

Aas IHM, Geitung JT. Choosing networks for picture archiving and communication systems and teleradiology. *J Telemed Telecare.* 2003;9 Suppl 1:S27-9. PMID: 12952712

Exclusion: Not HIE

Adler-Milstein J, DesRoches CM, Furukawa MF, et al. More than half of US hospitals have at least a basic EHR, but stage 2 criteria remain challenging for most. *Health Aff (Millwood)*. 2014;33(9):1664-71. PMID: 25104826

Exclusion: Not HIE

Agarwal M, Bourgeois J, Sodhi S, et al. Updating a patient-level ART database covering remote health facilities in Zomba district, Malawi: Lessons learned. *Public Health Action*. 2013;3(2):175-9.

Exclusion: Not HIE

Ahmed S, Bartlett SJ, Ernst P, et al. Effect of a web-based chronic disease management system on asthma control and health-related quality of life: study protocol for a randomized controlled trial. *Trials*. 2011;12:260. PMID: 22168530

Exclusion: Wrong study design

Allen A, Des Jardins TR, Heider A, et al. Making it local: Beacon communities use health information technology to optimize care management. *Popul Health Manag*. 2014;17(3):149-58. PMID: 24476558

Exclusion: Wrong study design

Allen KA. Parent and Provider Decision-Making for Infants with HIE, Duke University; 2012.

Exclusion: Not HIE

Allender S, Nichols M, Foulkes C, et al. The development of a network for community-based obesity prevention: the CO-OPS Collaboration. *BMC Public Health*. 2011;11:132. PMID: 21349185

Exclusion: Not HIE

Ancker JS, Miller MC, Patel V, et al. Sociotechnical challenges to developing technologies for patient access to health information exchange data. *J Am Med Inform Assoc*. 2014;21(4):664-70. PMID: 24064443

Exclusion: No data relevant to a Key Question

Anderson JG. Social, ethical and legal barriers to e-health. *Int J Med Inf*. 2007;76(5-6):480-3. PMID: 17064955

Exclusion: Not HIE

Andrade SE, Davis RL, Cheetham TC, et al. Medication Exposure in Pregnancy Risk Evaluation Program. *Matern Child Health J*. 2012;16(7):1349-54. PMID: 22002179

Exclusion: Not HIE

Angst CM. Protect my privacy or support the common-good? Ethical questions about electronic health information exchanges. *J Bus Ethics*. 2009;90(Suppl 2):169-78.

Exclusion: Wrong study design

Appleby C. NYCLIX: New York HIE life. An expansive HIE network has taken shape in the nation's most densely populated urban area. *Healthc Inform.* 2010;27(10):29-31. PMID: 21049716

Exclusion: Wrong study design

Appleby C. Surfing the HIE. The Santa Cruz information exchange experience offers lessons on what works. *Healthc Inform.* 2010;27(6):68-9. PMID: 20593734

Exclusion: Wrong study design

Arar NH, Wen L, McGrath J, et al. Communicating about medications during primary care outpatient visits: the role of electronic medical records. *Inform Prim Care.* 2005;13(1):13-22. PMID: 15949171

Exclusion: Not HIE

Asangansi I, Braa K. The emergence of mobile-supported national health information systems in developing countries... *MEDINFO 2010: Proceedings of the 13th World Congress on Medical Informatics, Part 1. Stud Health Technol Inform.* 2010;160:540-4.

Exclusion: No data relevant to a Key Question

Aschman DJ, Abshire TC, Shapiro AD, et al. A community-based partnership to promote information infrastructure for bleeding disorders. *Am J Prev Med.* 2011;41(6 Suppl 4):S332-7. PMID: 22099355

Exclusion: No data relevant to a Key Question

Ash JS, Guappone KP. Qualitative evaluation of health information exchange efforts. *J Biomed Inform.* 2007;40(6 Suppl):S33-9. PMID: 17904914

Exclusion: Wrong study design

Ashley L, Jones H, Forman D, et al. Feasibility test of a UK-scalable electronic system for regular collection of patient-reported outcome measures and linkage with clinical cancer registry data: The electronic Patient-reported Outcomes from Cancer Survivors (ePOCS) system. *BMC Med Inform Decis Mak.* 2011;11:66. PMID: 22029686

Exclusion: Wrong study design

Badia CM, Duenas AE, Martinez OM, et al. My health log. *Eur J Intern Med.* 2011;22:S56-S7.

Exclusion: Wrong study design

Bah S, Alharthi H, El Mahalli AA, et al. Annual Survey on the Level and Extent of Usage of Electronic Health Records in Government-related Hospitals. *Perspect Health Inf Manag.* 2011;8(4):1-12. PMID: 22016668

Exclusion: Not HIE

Balas A, Al Sanousi A. Interoperable electronic patient records for health care improvement. *Stud Health Technol Inform.* 2009;150:19-23. PMID: 19745258

Exclusion: Wrong study design

Balasingham I, Ihlen H, Leister W, et al. Communication of medical images, text, and messages in inter-enterprise systems: a case study in Norway. *IEEE Trans Inf Technol Biomed.*

2007;11(1):7-13. PMID: 17249398

Exclusion: Wrong study design

Balka E, Tolar M, Coates S, et al. Socio-technical issues and challenges in implementing safe patient handovers: Insights from ethnographic case studies. *Int J Med Inf.* 2013;82(12):e345-e57.

PMID: 23218926

Exclusion: Not HIE

Ball MJ, Gold J. Banking on health: Personal records and information exchange. *J Healthc Inf Manag.* 2006;20(2):71-83. PMID: 16669591

Exclusion: Wrong study design

Bansal M, Grannis S, Kansky J, et al. Evaluating cost differences among operational teams supporting the Indiana health information exchange. *Value Health.* 2009;12(3):A87.

Exclusion: No data relevant to a Key Question

Bara D, McPhillips-Tangum C, Wild EL, et al. Integrating child health information systems in public health agencies. *J Public Health Manag Pract.* 2009;15(6):451-8. PMID: 19823148

Exclusion: Not HIE

Barbarito F, Pinciroli F, Mason J, et al. Implementing standards for the interoperability among healthcare providers in the public regionalized Healthcare Information System of the Lombardy Region. *J Biomed Inform.* 2012;45(4):736-45. PMID: 22285983

Exclusion: Wrong study design

Barrows RC, Jr., Ezzard J. Technical architecture of ONC-approved plans for statewide health information exchange. *AMIA Annu Symp Proc.* 2011;2011:88-97. PMID: 22195059

Exclusion: No data relevant to a Key Question

Basch P. Will interoperable HIT lead to a net gain or to a net loss for physicians? (2/23/2005). *Health Aff (Millwood).* 2005;Suppl Web Exclusives:W5-S-1-W5-S-3; author reply W5-S-3-W5-S-6. PMID: 16440450

Exclusion: Wrong study design

Bassi J, Lau F. Measuring value for money: a scoping review on economic evaluation of health information systems. *J Am Med Inform Assoc.* 2013;20(4):792-801. PMID: 23416247

Exclusion: Not HIE

Bates DW, Gawande AA. Improving Safety with Information Technology. *N Engl J Med.* 2003;348(25):2526-34. PMID: 12815139

Exclusion: Not HIE

Beckjord EB, Rechis R, Nutt S, et al. What Do People Affected by Cancer Think About Electronic Health Information Exchange? Results From the 2010 LIVESTRONG Electronic Health Information Exchange Survey and the 2008 Health Information National Trends Survey. *J Oncol Pract.* 2011;7(4):237-41. PMID: 22043188

Exclusion: Wrong study design

Bell DS, Cima L, Seiden DS, et al. Effects of laboratory data exchange in the care of patients with HIV. *Int J Med Inf.* 2012;81(10):e74-82. PMID: 22906370

Exclusion: Not HIE

Ben-Assuli O, Shabtai I, Leshno M, et al. EHR in emergency rooms: Exploring the effect of key information components on main complaints. *J Med Syst.* 2014;38(4) PMID: 24687240

Exclusion: No comparison group

Benford MS, Slack CB. Development of a statewide maternal and child health information network... MATCH. *Comput Nurs.* 1989;7(1):9-14. PMID: 2924201

Exclusion: Wrong study design

Bergmann J, Bott OJ, Pretschner DP, et al. An e-consent-based shared EHR system architecture for integrated healthcare networks. *Int J Med Inform.* 2007;76(2-3):130-6. PMID: 16971171

Exclusion: Wrong study design

Berry JG, Goldmann DA, Mandl KD, et al. Health information management and perceptions of the quality of care for children with tracheotomy: a qualitative study. *BMC Health Serv Res.* 2011;11:117. PMID: 21605385

Exclusion: Not HIE

Biondich PG, Grannis SJ. The Indiana Network for Patient Care: an integrated clinical information system informed by over thirty years of experience. *J Public Health Manag Pract.* 2004;S81-6. PMID: 15643364

Exclusion: No data relevant to a Key Question

Bipartisan Policy Center. Clinician Perspectives on Electronic Health Information Sharing for Transitions of Care 2012. Available at:

https://www.acponline.org/running_practice/technology/bpc_clinician_survey_100312.pdf.

Accessed November 10, 2014.

Exclusion: Wrong study design

Black CD, Burchill CA, Roos LL. The Population Health Information System: data analysis and software. *Med Care.* 1995;33(12 Suppl):DS127-31. PMID: 7500665

Exclusion: Wrong study design

Blaya JA, Shin SS, Yagui MJA, et al. A web-based laboratory information system to improve quality of care of tuberculosis patients in Peru: Functional requirements, implementation and usage statistics. *BMC Med Inform Decis Mak*. 2007;7 PMID: 17963522

Exclusion: Not HIE

Blobel B. Standards and solutions for architecture based, ontology driven and individualized pervasive health. *Stud Health Technol Inform*. 2012;177:147-57. PMID: 22942047

Exclusion: Not HIE

Bohren BF, Hadzikadic M. Turning medical data into decision-support knowledge. *Proc Annu Symp Comput Appl Med Care*. 1994:735-9. PMID: 7950022

Exclusion: Not HIE

Bonney W. Determinants in the acceptance of Health Level Seven (HL7) version 3 messaging standard. *Diss Abstr Int*. 2013;73(12-B(E)):No Pagination Specified.

Exclusion: Not HIE

Boockvar KS, Livote EE, Goldstein N, et al. Electronic health records and adverse drug events after patient transfer. *Qual Saf Health Care*. 2010;19(5):e16. PMID: 20724395

Exclusion: Not HIE

Bouhaddou O, Bennett J, Teal J, et al. Toward a Virtual Lifetime Electronic Record: the Department of Veterans Affairs experience with the Nationwide Health Information Network. *AMIA Annu Symp Proc*. 2012;2012:51-60. PMID: 23304272

Exclusion: No data relevant to a Key Question

Bouhaddou O, Cromwell T, Davis M, et al. Translating standards into practice: experience and lessons learned at the Department of Veterans Affairs. *J Biomed Inform*. 2012;45(4):813-23. PMID: 22285982

Exclusion: Not HIE

Bowen R, Carey S, Carter P, et al. HIE management and operational considerations. *J AHIMA*. 2011;82(5):56-61. PMID: 21667869

Exclusion: Wrong study design

Brailer DJ. Connection tops collection: peer-to-peer technology lets caregivers access necessary data, upon request, without using a repository. *Health Manag Technol*. 2001;22(8):28-9. PMID: 11499130

Exclusion: Wrong study design

Brailer DJ. From Santa Barbara to Washington: a person's and a nation's journey toward portable health information. *Health Aff*. 2007;26(5):w581-8. PMID: 17670776

Exclusion: Wrong study design

Branger PJ, van't Hooft A, van der Wouden JC, et al. Shared care for diabetes: supporting communication between primary and secondary care. *Int J Med Inf.* 1999;53(2-3):133-42. PMID: 10193883

Exclusion: Not HIE

Brattheim B, Faxvaag A, Toussaint P. When information sharing is not enough. *Stud Health Technol Inform.* 2011;169:359-63. PMID: 21893773

Exclusion: Wrong study design

Brelstaff G, Moehrs S, Anedda P, et al. Internet patient records: new techniques. *J Med Internet Res.* 2001;3(1):E8. PMID: 11720950

Exclusion: Not HIE

Brennan CP. Managed care and health information networks. *J Health Care Finance.* 1995;21(4):1-5. PMID: 7583779

Exclusion: No data relevant to a Key Question

Brocht DF, Abbott PA, Smith CA, et al. A clinic on wheels. A paradigm shift in the provision of care and the challenges of information infrastructure. *Comput Nurs.* 1999;17(3):109-13. PMID: 10341475

Exclusion: Wrong study design

Brokel JM. Capture, exchange and use data, information and knowledge within electronic health records. *Iowa Nurse Reporter.* 2007;20(1):1, 25, 7.

Exclusion: Wrong study design

Brokel JM. Iowa e-health project: planning for health information exchange with nursing standardized language with health information technology tools. *Iowa Nurse Reporter.* 2009;22(3):1.

Exclusion: Wrong study design

Brokel JM. Regional health information organization (RHIO) to exchange data. *Iowa Nurse Reporter.* 2007;20(2):4-5.

Exclusion: Wrong study design

Brown CVR, Foulkrod KH, Sadler HT, et al. Autologous blood transfusion during emergency trauma operations. *Arch Surg.* 2010;145(7):690-4. PMID: 20644133

Exclusion: Not HIE

Brown JS, Holmes JH, Shah K, et al. Distributed health data networks: a practical and preferred approach to multi-institutional evaluations of comparative effectiveness, safety, and quality of care. *Med Care.* 2010;48(6 Suppl):S45-51. PMID: 20473204

Exclusion: No data relevant to a Key Question

Brown ML, Riley GF, Potosky AL, et al. Obtaining long-term disease specific costs of care: application to Medicare enrollees diagnosed with colorectal cancer. *Med Care*. 1999;37(12):1249-59. PMID: 10599606

Exclusion: Not HIE

Buntin MB, Burke MF, Hoaglin MC, et al. The benefits of health information technology: a review of the recent literature shows predominantly positive results. *Health Aff (Millwood)*. 2011;30(3):464-71. PMID: 21383365

Exclusion: Systematic review not meeting our requirements

Burstin H, Clancy C. Primary care experience: crossing the chasm between theory and practice. *J Gen Intern Med*. 2004;19(10):1064-5. PMID: 15482561

Exclusion: Not HIE

Caldwell D. Health information exchange. *MLO Med Lab Obs*. 2012;44(11):46. PMID: 23173526

Exclusion: Wrong study design

Caldwell D. Management Q&A. Health information exchange. *MLO Med Lab Obs*. 2012;44(11):46.

Exclusion: Wrong study design

Callen J, Paoloni R, Li J, et al. Perceptions of the effect of information and communication technology on the quality of care delivered in emergency departments: a cross-site qualitative study. *Ann Emerg Med*. 2013;61(2):131-44. PMID: 23083964

Exclusion: No data relevant to a Key Question

Carr CM, Saef SH, Zhao J, et al. Can data from a health information exchange be used to describe patients who visit multiple emergency departments within a region? *Acad Emerg Med*. 2014;21(5):S141.

Exclusion: Not HIE

Carr K, Bangalore D, Benin A, et al. Leveraging the benefits of Health Information Technology to support healthcare delivery model redesign. *J Healthc Inf Manag*. 2006;20(1):31-41. PMID: 16429957

Exclusion: Not HIE

Cebul RD, Love TE, Jain AK, et al. Electronic health records and quality of diabetes care. *N Engl J Med*. 2011;365(9):825-33. PMID: 21879900

Exclusion: Not HIE

Centers for Disease C, Prevention. State electronic disease surveillance systems --- United States, 2007 and 2010. *MMWR Morb Mortal Wkly Rep*. 2011;60(41):1421-3. PMID: 22012115

Exclusion: Not HIE

Centorrino F, Mark TL, Talamo A, et al. Health and economic burden of metabolic comorbidity among individuals with bipolar disorder. *J Clin Psychopharmacol*. 2009;29(6):595-600. PMID: 19910727

Exclusion: Not HIE

Chang I, Hwang H-G, Hung M-C, et al. Factors affecting cross-hospital exchange of Electronic Medical Records. *Information & Management*. 2009;46(2):109-15.

Exclusion: Not HIE

Chaudhry B, Wang J, Wu S, et al. Systematic review: impact of health information technology on quality, efficiency, and costs of medical care. *Ann Intern Med*. 2006;144(10):742-52. PMID: 16702590

Exclusion: Systematic review not meeting our requirements

Chen C, Garrido T, Chock D, et al. The Kaiser Permanente electronic health record: Transforming and streamlining modalities of care. *Health Aff*. 2009;28(2):323-33. PMID: 19275987

Exclusion: Not HIE

Chen R, Enberg G, Klein GO. Julius--a template based supplementary electronic health record system. *BMC Med Inform Decis Mak*. 2007;7:10. PMID: 17474997

Exclusion: No data relevant to a Key Question

Cheung K-C, van der Veen W, Bouvy ML, et al. Classification of medication incidents associated with information technology. *J Am Med Inform Assoc*. 2014;21(e1):e63-70. PMID: 24064444

Exclusion: Not HIE

Cimino JJ, Frisse ME, Halamka J, et al. Consumer-mediated health information exchanges: The 2012 ACMI debate. *J Biomed Inform*. 2014;48:5-15. PMID: 24561078

Exclusion: Wrong study design

Ciriello JN, Kulatilaka N. Smart health community: the hidden value of health information exchange. *Am J Manag Care*. 2010;16(12 Suppl HIT):SP31-6. PMID: 21314218

Exclusion: Wrong study design

Clancy GP, Duffy FD. Going "all in" to transform the Tulsa community's health and health care workforce. *Acad Med*. 2013;88(12):1844-8. PMID: 24128637

Exclusion: Wrong study design

Coffman T, Porter JP, Frisse ME. Reducing HIE costs through real-time data feed visualizations. *AMIA Annu Symp Proc*. 2008:913. PMID: 18999214

Exclusion: Not HIE

Collin S, Reeves BC, Hendy J, et al. Implementation of computerised physician order entry (CPOE) and picture archiving and communication systems (PACS) in the NHS: quantitative before and after study. *BMJ*. 2008;337(a939):1-8. PMID: 18703655

Exclusion: Not HIE

Collins SA, Bakken S, Vawdrey DK, et al. Model development for EHR interdisciplinary information exchange of ICU common goals. *Int J Med Inf*. 2011;80(8):e141-9. PMID: 20974549

Exclusion: Not HIE

Conn J. RHIOs make it work. Data-sharing project connects three networks. *Mod Healthc*. 2006;36(7):22. PMID: 16515062

Exclusion: Wrong study design

Constantinides P, Barrett M. Large-scale ICT innovation, power, and organizational change: The case of a regional health information network. *J Appl Behav Sci*. 2006;42(1):76-90.

Exclusion: Wrong study design

Corado C, Cashy J, Kho A, et al. Fragmented care among stroke patients at 4 Chicago hospitals. *Stroke*. 2014;45 **Exclusion:** Not HIE

Cormont S, Vandebussche P-Y, Buemi A, et al. Implementation of a platform dedicated to the biomedical analysis terminologies management. *AMIA Annu Symp Proc*. 2011;2011:1418-27. PMID: 22195205

Exclusion: Not HIE

Costa C, Ferreira C, Bastiao L, et al. Dicoogle - an open source peer-to-peer PACS. *J Digit Imaging*. 2011;24(5):848-56. PMID: 20981467

Exclusion: Not HIE

Crosson JC, Ohman-Strickland PA, Cohen DJ, et al. Typical electronic health record use in primary care practices and the quality of diabetes care. *Ann Fam Med*. 2012;10(3):221-7. PMID: 22585886

Exclusion: Not HIE

Cummins MR, Crouch BI, Gesteland P, et al. Electronic information exchange between emergency departments and poison control centers: a Delphi study. *Clin Toxicol (Phila)*. 2012;50(6):503-13. PMID: 22612793

Exclusion: No data relevant to a Key Question

da Silva KR, Costa R, Crevelari ES, et al. Glocal clinical registries: pacemaker registry design and implementation for global and local integration--methodology and case study. *PLoS ONE*. 2013;8(7):e71090. PMID: 23936257

Exclusion: Not HIE

da Silva ME, Coeli CM, Ventura M, et al. Informed consent for record linkage: a systematic review. *J Med Ethics*. 2012;38(10):639-42. PMID: 22403083

Exclusion: Not HIE

D'Amore JD, Mandel JC, Kreda DA, et al. Are Meaningful Use Stage 2 certified EHRs ready for interoperability? Findings from the SMART C-CDA Collaborative. *J Am Med Inform Assoc*. 2014;21(6):1060-8. PMID: 24970839

Exclusion: Not HIE

D'Amore JD, Sittig DF, Ness RB. How the continuity of care document can advance medical research and public health. *Am J Public Health*. 2012;102(5):e1-4. PMID: 22420795

Exclusion: Wrong study design

D'Amore JD, Sittig DF, Wright A, et al. The promise of the CCD: challenges and opportunity for quality improvement and population health. *AMIA Annu Symp Proc*. 2011;2011:285-94. PMID: 22195080

Exclusion: Not HIE

Daniel GW, Ewen E, Willey VJ, et al. Efficiency and economic benefits associated with the use of a payer-based electronic health record in an emergency department among a health insured population. *Value Health*. 2009;12(3):A14.

Exclusion: Not HIE

Darmon D, Sauvart R, Staccini P, et al. Which functionalities are available in the electronic health record systems used by French general practitioners? An assessment study of 15 systems. *Int J Med Inf*. 2014;83(1):37-46. PMID: 24231269

Exclusion: Not HIE

Daskalakis S, Katharaki M, Mantas J. The use of data envelopment analysis to measure the efficiency and interoperability of information technology in Greek public healthcare organisations. *Journal on Information Technology in Healthcare*. 2008;6(3):188-96.

Exclusion: Not HIE

Davidson SJ, Zwemer FL, Jr., Nathanson LA, et al. Where's the beef? The promise and the reality of clinical documentation. *Acad Emerg Med*. 2004;11(11):1127-34. PMID: 15528575

Exclusion: Not HIE

de Brantes F, Emery DW, Overhage JM, et al. The potential of HIEs as infomediaries. *J Healthc Inf Manag*. 2007;21(1):69-75. PMID: 17299928

Exclusion: Wrong study design

de la Torre I, Diaz FJ, Anton M, et al. Performance evaluation of a web-based system to exchange Electronic Health Records using Queueing model (M/M/1). *J Med Syst*. 2012;36(2):915-24. PMID: 20703642

Exclusion: Not HIE

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Exclusion: Wrong study design

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Exclusion: Wrong study design

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Exclusion: Not HIE

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Exclusion: Not HIE

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Exclusion: Not HIE

Appendix E. Risk of Bias Assessment Criteria

Our assessment of risk of bias will be based on the recommendations in the AHRQ Methods Guide for Effectiveness and Comparative Effectiveness Reviews (hereafter, Methods Guide).¹ Included studies will be classified according to type of design (e.g., randomized trial, nonrandomized trial, observational study, etc.) as part of the data abstraction phase, and each major type of study will be assessed for bias according to relevant criteria. These criteria included questions to assess selection bias, performance bias, detection bias, attrition bias, and reporting bias (i.e. those about adequacy of randomization, similarity of groups at baseline, appropriateness of the comparators, consideration of concurrent interventions or unintended exposures, quantity of missing data, methods of handling missing data, identification and assessment of important confounding variables, use of intention-to-treat analysis, reliability and validity of outcome measures, and reporting of pre specified outcomes).

Randomized, Controlled Trials

Criteria:

Selection bias

- Was randomization adequate?
- Was allocation concealment adequate?
- Were groups similar at baseline?
- Did the study maintain comparable groups throughout the study?
- Was the eligibility criteria specified?

Detection bias

- Was the study adequately blinded (outcome assessor, care provider, and patient)?

Attrition bias

- Was the loss to followup not differential or high?

Reporting bias

- Did the study report attrition, crossovers, adherence, and contamination?
- Was an intention-to-treat analysis used?
- Were outcomes prespecified?

Cohort, case-control, and other observational studies

Criteria:

Selection bias

- Are the comparison groups or time periods appropriate?
- Were the inclusion and exclusion criteria specified and applied equally to each group?
- Did the design and analyses account for important potential confounding and modifying variables appropriately?

- Were valid and reliable measures used (inclusion/exclusion, confounding, outcomes)?

Detection bias

- Were non-biased and valid ascertainment methods used (inclusion/exclusion, confounding, outcomes)?
- Was the timing and/or time period for the measurement of the intervention and outcomes appropriate?

Attrition bias

- Was there NO missing data? If missing data, was it handled appropriately?

Reporting bias

- Were outcomes prespecified and were prespecified outcomes reported?

Definition of ratings based on above criteria:

Low risk of bias:

Studies rated “low risk of bias” will be considered to have the least risk of bias, and their results will be considered valid. Low risk of bias studies include clear descriptions of the population, setting, interventions, and comparison groups clear reporting of missing data; appropriate means for preventing bias; and appropriate measurement of outcomes.

Moderate risk of bias:

Studies rated “moderate risk of bias” will be susceptible to some bias, though not enough to necessarily invalidate the results. These studies may not meet all the criteria for a rating of low risk of bias, but do not have flaws likely to cause major bias. The study may be missing information, making it difficult to assess limitations and potential problems. The moderate risk of bias category is broad, and studies with this rating will vary in their strengths and weaknesses. The results of some moderate risk of bias studies are likely to be valid, while others may be only possibly valid.

High risk of bias:

Studies rated “high risk of bias” will have significant flaws that imply biases of various types that may invalidate the results. They will have a serious or “fatal” flaw in design, analysis, or reporting; large amounts of missing information; or discrepancies in reporting. The results of these studies will be least as likely to reflect flaws in the study design as the true difference between the compared interventions. We will not exclude studies rated as being high risk of bias a priori, but high risk of bias studies will be considered to be less reliable than lower risk of bias studies when synthesizing the evidence, particularly if discrepancies between studies are present.

Surveys, focus groups, and interview studies

Criteria

Selection bias

1. Is the sampling strategy or selection criteria reported and appropriate?

2. Are the response or participation rates reported and are they acceptable given the type of study?
3. Are characteristics (e.g., demographics) of respondents/participants reported?

Detection bias

4. Is how the questions were developed/selected reported and is it appropriate?
5. Were confounders considered (could be in analysis or presentation, such as stratifying results)?

Other

6. Is analysis appropriate (given the type of data)?

Reference

1. Methods Guide for Effectiveness and Comparative Effectiveness Reviews. AHRQ Publication Number 10(14)-EHC062-EF. Rockville, MD: Agency for Healthcare Research and Quality. January 2014. Available at: www.effectivehealthcare.ahrq.gov. Accessed April 18, 2014. PMID: 21433403.

Appendix F. Strength of Evidence Criteria¹

The set of five required domains comprises the main constructs that Evidence-based Practice Centers (EPCs) should use for all major outcomes and comparisons of interest. As briefly defined below in Table F1, these domains represent related but separate concepts and each is scored independently. The concepts are explained in more detail below.

Table F1. Required domains and their definitions

Domain	Definition and Elements	Score and Application
Study Limitations	<p>Study limitations is the degree to which the included studies for a given outcome have a high likelihood of adequate protection against bias (i.e., good internal validity), assessed through two main elements:</p> <ul style="list-style-type: none"> • Study design: Whether RCTs or other designs such as nonexperimental or observational studies. • Study conduct. Aggregation of ratings of risk of bias of the individual studies under consideration. 	<p>Score as one of three levels, separately by type of study design:</p> <ul style="list-style-type: none"> • Low level of study limitations • Medium level of study limitations • High level of study limitations
Directness	<p>Directness relates to (a) whether evidence links interventions directly to a health outcome of specific importance for the review, and (b) for comparative studies, whether the comparisons are based on head-to-head studies. The EPC should specify the comparison and outcome for which the SOE grade applies.</p> <p>Evidence may be indirect in several situations such as:</p> <ul style="list-style-type: none"> • The outcome being graded is considered intermediate (such as laboratory tests) in a review that is focused on clinical health outcomes (such as morbidity, mortality). • Data do not come from head-to-head comparisons but rather from two or more bodies of evidence to compare interventions A and B—e.g., studies of A vs. placebo and B vs. placebo, or studies of A vs. C and B vs. C but not direct comparisons of A vs. B. • Data are available only for proxy respondents (e.g., obtained from family members or nurses) instead of directly from patients for situations in which patients are capable of self-reporting and self-report is more reliable. <p>Indirectness always implies that more than one body of evidence is required to link interventions to the most important health outcome.</p>	<p>Score as one of two levels:</p> <ul style="list-style-type: none"> • Direct • Indirect <p>If the domain score is indirect, EPCs should specify what type of indirectness accounts for the rating.</p>
Consistency	<p>Consistency is the degree to which included studies find either the same direction or similar magnitude of effect. EPCs can assess this through two main elements:</p> <ul style="list-style-type: none"> • Direction of effect: Effect sizes have the same sign (that is, are on the same side of no effect or a MID) • Magnitude of effect: The range of effect sizes is similar. EPCs may consider the overlap of CIs when making this evaluation. <p>The importance of direction vs. magnitude of effect will</p>	<p>Score as one of three levels:</p> <ul style="list-style-type: none"> • Consistent • Inconsistent • Unknown (e.g., single study) <p>Single-study evidence bases (including mega-trials) cannot be judged with respect to consistency. In that instance, use “Consistency unknown (single</p>

Domain	Definition and Elements	Score and Application
	depend on the key question and EPC judgments.	study).”
Precision	<p>Precision is the degree of certainty surrounding an effect estimate with respect to a given outcome, based on the sufficiency of sample size and number of events.</p> <ul style="list-style-type: none"> • A body of evidence will generally be imprecise if the OIS is not met. OIS refers to the minimum number of patients (and events when assessing dichotomous outcomes) needed for an evidence base to be considered adequately powered. • If EPCs performed a meta-analysis, then EPCs may also consider whether the CI crossed a threshold for an MID. • If a meta-analysis is infeasible or inappropriate, EPCs may consider the narrowness of the range of CIs or the significance level of p-values in the individual studies in the evidence base. 	<p>Score as one of two levels:</p> <ul style="list-style-type: none"> • Precise • Imprecise <p>A precise estimate is one that would allow users to reach a clinically useful conclusion (e.g., treatment A is more effective than treatment B).</p>
Reporting Bias	<p>Reporting bias results from selectively publishing or reporting research findings based on the favorability of direction or magnitude of effect. It includes:</p> <ul style="list-style-type: none"> • Study publication bias, i.e., nonreporting of the full study. • Selective outcome reporting bias, i.e., nonreporting (or incomplete reporting) of planned outcomes or reporting of unplanned outcomes. • Selective analysis reporting bias, i.e., reporting of one or more favorable analyses for a given outcome while not reporting other, less favorable analyses. <p>Assessment of reporting bias for individual studies depends on many factors—e.g. availability of study protocols, unpublished study documents, and patient-level data. Detecting such bias is likely with access to all relevant documentation and data pertaining to a journal publication, but such access is rarely available.</p> <p>Because methods to detect reporting bias in observational studies are less certain, this guidance does not require EPCs to assess it for such studies.</p>	<p>Score as one of two levels:</p> <ul style="list-style-type: none"> • Suspected • Undetected <p>Reporting bias is suspected when:</p> <ul style="list-style-type: none"> • Testing for funnel plot asymmetry demonstrates a substantial likelihood of bias, <p>And/or</p> <ul style="list-style-type: none"> • A qualitative assessment suggests the likelihood of missing studies, analyses, or outcomes data that may alter the conclusions from the reported evidence. <p>Undetected reporting bias includes all alternative scenarios.</p>

Abbreviations: CI = confidence interval; EPC = Evidence-based Practice Center; MID = minimally important difference; OIS = optimal information size; RCT = randomized controlled trial; SOE = strength of evidence

Study Limitations Domain Definition

Scoring the study limitations domain is the essential starting place for grading strength of the body of evidence. It refers to the judgment that the findings from included studies of a treatment (or treatment comparison) for a given outcome are adequately protected against bias (i.e., have good internal validity), based on the design and conduct of those studies. That is, EPCs assess the ability of the evidence to yield an accurate estimate of the true effect without bias (nonrandom error).

Directness Domain Definition

Directness of evidence expresses how closely available evidence measures an outcome of interest. Assessing directness has two parts: directness of outcomes and directness of comparisons. Applicability of evidence (external validity) is considered explicitly but separately from strength of evidence.

Consistency Domain Definition

Consistency refers to the degree of similarity in the direction of effects or the degree of similarity in the effect sizes (magnitudes of effect) across individual studies within an evidence base. EPCs may choose which of these two notions of consistency (direction or magnitude) they are scoring; they should be explicit about this choice.

Precision Domain Definition

Precision is the degree of certainty surrounding an estimate of effect with respect to an outcome. It is based on the potential for random error evaluated through the sufficiency of sample size and, in the case of dichotomous outcomes, the number of events. A precise body of evidence should enable decisionmakers to draw conclusions about whether one treatment is inferior, equivalent, or superior to another.

Reporting Bias Definition

Reporting bias occurs when authors, journals, or both decide to publish or report research findings based on their direction or magnitude of effect. Table 2 defines the three main types of reporting bias that either authors or journals can introduce: publication bias and outcome and analysis reporting bias.

Four Strength of Evidence Levels

The four levels of grades are intended to communicate to decisionmakers EPCs' confidence in a body of evidence for a single outcome of a single treatment comparison. Although assigning a grade requires judgment, having a common understanding of the interpretation will be useful for helping EPCs as they conduct their own global assessment and for improving consistency across reviewers and EPCs.

Table F2 summarizes the four levels of grades that EPCs use for the overall assessment of the body of evidence. Grades are denoted high, moderate, low, and insufficient. They are not designated by Roman numerals or other symbols. EPCs should apply discrete grades and should not use designations such as “low to moderate” strength of evidence.

Table F2. Strength of evidence grades and definitions

Grade	Definition
High	We are very confident that the estimate of effect lies close to the true effect for this outcome. The body of evidence has few or no deficiencies. We believe that the findings are stable, i.e., another study would not change the conclusions.
Moderate	We are moderately confident that the estimate of effect lies close to the true effect for this outcome. The body of evidence has some deficiencies. We believe that the findings are likely to be stable, but some doubt remains.
Low	We have limited confidence that the estimate of effect lies close to the true effect for this outcome. The body of evidence has major or numerous deficiencies (or both). We believe that additional evidence is needed before concluding either that the findings are stable or that the estimate of effect is close to the true effect.
Insufficient	We have no evidence, we are unable to estimate an effect, or we have no confidence in the estimate of effect for this outcome. No evidence is available or the body of evidence has unacceptable deficiencies, precluding reaching a conclusion.

Each level has two components. The first, principal definition concerns the level of confidence that EPCs place in the estimate of effect (direction or magnitude of effect) for the benefit or harm; this equates to their judgment as to how much the evidence reflects a true effect. The second, subsidiary definition involves an assessment of the level of deficiencies in the body of evidence and belief in the stability of the findings, based on domain scores and a more holistic, summary appreciation of the possibly complex interaction among the individual domains.

Assigning a grade of high, moderate, or low implies that an evidence base is available from which to estimate an effect for either the benefit or the harm. The designations of high, moderate, and low should convey how confident EPCs would be about decisions based on evidence of differing grades, which can be based on either quantitative or qualitative assessment.

For comparative effectiveness questions, the comparison is typically a choice of either direction ($A > B$, $A = B$, $A < B$) or magnitude (difference between A and B). In some instances assigning different grades regarding the direction and the magnitude of an effect may be appropriate. An example of this situation is when studies consistently find that an intervention improves an outcome (e.g., apnea-hypopnea index is reduced by a statistically significant amount

or beyond a minimally important difference), but the degree of heterogeneity about the estimate is high (e.g., range -10 to -46 events/minute; $I^2 = 86\%$).

The importance of the distinctions among high, moderate, and low levels (and the distinction with insufficient strength of evidence) can vary by the type of outcome, comparison, and decisionmaker. EPCs understand that some stakeholders may want to take action only when evidence is of high or moderate strength, whereas others may want to understand clearly the implications of low versus insufficient evidence. Even when strength of evidence is low or insufficient, consumers, clinicians, and policymakers may find themselves in the position of having to make choices and decisions, and they may consider factors other than the evidence from a specific systematic review, such as patient values and preferences, costs, or resources.

Reference

1. Methods Guide for Effectiveness and Comparative Effectiveness Reviews. AHRQ Publication No. 10(13)-EHC063-EF. Rockville (MD) :Agency for Healthcare Research and Quality. January 2014. Available at: www.effectivehealthcare.ahrq.gov.

Appendix G. Evidence Table

Table G1. Evidence Table

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Abramson, <i>et al.</i> , 2012 ⁶⁵	Survey of hospitals for adoption of EHRs and HIE	Measure EHR and HIE adoption in New York State hospitals	New York State	Hospital	Survey of hospitals	May-December 2009	Various HIEs around New York State
Abramson, <i>et al.</i> , 2014 ⁶⁶	Survey of nursing homes for EHR and HIE adoption	Measure EHR and HIE adoption in New York State nursing homes	New York State	Nursing homes	Survey of nursing homes	November 2011-March 2012	Nursing homes around New York State
Adjerid and Padman, 2011 ¹⁴²	Association of state "consent prior to disclosure" laws with number of operational HIEs	Analyze data from compilation of privacy laws and Adler-Milstein 2009 analysis of RHIOs	U.S.	Any	Data from compilation of privacy laws and Adler-Milstein 2009 analysis of RHIOs	2009-2010	All in U.S.
Adler-Milstein and Jha, 2014 ⁹³	Measurement of HIE usage among U.S. hospitals	Analyze data from annual AHA survey of hospital IT	U.S.	Any	Hospital survey database, augmented with market and other characteristic data	Late 2012	All in U.S.
Adler-Milstein, Bates and Jha, 2011 ⁶⁸	Survey of RHIOs	Measure number of RHIOs, participation in them by ambulatory practices and hospitals, and number financially viable	U.S.	Any	Survey of RHIOs	June 2008-December 2009	All in U.S.

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Abramson, <i>et al.</i> , 2012 ⁶⁵	Type of data exchanged NR	NR	All 205 hospitals in New York State	Various HIEs	All hospitals in New York State	NA
Abramson, <i>et al.</i> , 2014 ⁶⁶	Exchange of data (NR) with pharmacies, lab, hospitals, physician offices, and RHIO	NR	All 632 nursing homes in New York State	Various HIEs	All nursing homes in New York State	NA
Adjerid and Padman, 2011 ¹⁴²	All types	NA	313 HIE initiatives from 2004-2009	All 313 HIE initiatives	HIE status; state health disclosure law status	None
Adler-Milstein and Jha, 2014 ⁹³	All types	NA	2,849 U.S. hospitals that responded to AHA IT survey	All of population	All hospitals responding to survey	None
Adler-Milstein, Bates and Jha, 2011 ⁶⁸	All types provided by a RHIO	NA	197 organizations meeting definition of RHIO	165 RHIOs	All RHIOs	Not meeting definition of RHIO

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Abramson, <i>et al.</i> , 2012 ⁶⁵	None	Participation in HIE	Participate in HIE (exchange of data)	NA	Survey
Abramson, <i>et al.</i> , 2014 ⁶⁶	None	Participation in HIE	Participate in HIE (exchange of data)	NA	Survey
Adjerid and Padman, 2011 ¹⁴²	None	Total, operational, and failed HIE	-Health disclosure law -Population -Per capita GDP	HIE size not accounted for	Econometric models
Adler-Milstein and Jha, 2014 ⁹³	None	Participating in HIE	-Ownership -Market position -Size -Teaching status -Cardiac ICU -System affiliation -Medicaid admissions -EHR system	NA	OR of likelihood of participation
Adler-Milstein, Bates and Jha, 2011 ⁶⁸	None	Operational RHIOs, supporting stage 1 meaningful use, ambulatory practices and hospitals participating in RHIOs, and number of financially viable	Operational RHIOs, supporting stage 1 meaningful use, ambulatory practices and hospitals participating in RHIOs, and number of financially viable	NA	Survey

Author, year	Results
Abramson, <i>et al.</i> , 2012 ⁶⁵	23% of respondent hospitals participate and exchange data vs. 37% participate but do not exchange data vs. 40% do not participate
Abramson, <i>et al.</i> , 2014 ⁶⁶	54.4% participate in HIE, OR of participating in HIE: 2.26 more likely when have EHR Exchange with providers when EHR 59.7% within system vs. 31.3% outside system HIE highest usage Pharmacies: 41.8% Labs: 38.5% Hospitals: 38.5%
Adjerid and Padman, 2011 ¹⁴²	States with stronger privacy laws have more operational HIEs, fewer failed HIEs, and take less time to reach operational status.
Adler-Milstein and Jha, 2014 ⁹³	-30% of hospitals engage in HIE, varying widely by state -For-profit hospitals less likely to engage than nonprofit hospitals. Hospitals with larger market share or in less competitive markets more likely to exchange
Adler-Milstein, Bates and Jha, 2011 ⁶⁸	-75 operational RHIOs, covering 14% of U.S. hospitals and 3% of ambulatory practices -13 supporting meaningful use, covering 3% of hospitals, 0.9% of ambulatory practices; 67% not meeting criteria for financial viability

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Adler-Milstein, Bates and Jha, 2013 ²²	Survey of organizations facilitating HIE	Measurement of types of data exchanged, organizations involved, and sources of financial support	U.S.	Any	Survey of HIE organizations	August-November 2012	All in U.S.
Adler-Milstein, DesRoches and Jha, 2011 ⁹²	Measurement of AHA survey data about HIE	Measurement of participation in a regional HIO and exchange of data with hospitals or ambulatory providers of a different system	U.S.	Hospital	Hospital survey database	AHA survey from spring-summer 2009	All in U.S.
Adler-Milstein, <i>et al.</i> , 2008 ⁷⁰	Survey of RHIOs	Measurement of activities and financing of functioning RHIOs	U.S.	Any	Survey of RHIOs	July 2006-March 2007	All in U.S.
Adler-Milstein, Bates and Jha, 2009 ⁶⁷	Survey of operational RHIOs	Measurement of types of data exchanged, organizations involved, and sources of financial support	U.S.	Any	Survey of RHIOs	2008, following up of survey from 2007	All in U.S.
Adler-Milstein, Landefeld and Jha, 2010 ⁶⁹	Survey of RHIOs	Measure factors associated with becoming operational and achieving financial viability	U.S.	Any	Survey of RHIOs	Mid-2008	All in U.S.

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Adler-Milstein, Bates and Jha, 2013 ²²	All types	NA	221 organizations facilitating HIE	NA	All organizations facilitating HIE	Organizations only participating in HIE
Adler-Milstein, DesRoches and Jha, 2011 ⁹²	All types	NA	3,101 acute-care, nonfederal hospitals that were U.S. based members of AHA	Various HIEs	All acute-care, nonfederal hospitals that were U.S. based members of AHA	Hospitals that were federal or nonacute or were not members of AHA
Adler-Milstein, <i>et al.</i> , 2008 ⁷⁰	All types provided by a RHIO	NA	138 organizations meeting definition of RHIO	32 RHIOs actively exchanging data	20 RHIOs actively exchanging clinical data for 5000+ patients	Not actively exchanging data
Adler-Milstein, Bates and Jha, 2009 ⁶⁷	All types	NA	207 organizations defined as RHIOs	All 44 operational RHIOs exchanging data for ≥5,000 patients	All RHIOs exchanging data for ≥5,000 patients	RHIOs not exchanging data or doing so for <5,000 patients
Adler-Milstein, Landefeld and Jha, 2010 ⁶⁹	All types provided by a RHIO	NA	131 organizations meeting definition of RHIO	81 RHIOs currently or planning to exchange data for 5000+ patients	81 RHIOs currently or planning to exchange data for 5000+ patients	Not meeting definition of RHIO

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Adler-Milstein, Bates and Jha, 2013 ²²	None	Operational exchange or data, types of data exchanged, barriers to exchange	Operational exchange or data, types of data exchanged, barriers to exchange	NA	Survey
Adler-Milstein, DesRoches and Jha, 2011 ⁹²	None	Participation in HIE and market characteristics	-Hospital profit status -Market share -Teaching status -Size -Cardiac ICU -System affiliation -Medicaid admissions -EHR system	NA	Analysis of database
Adler-Milstein, <i>et al.</i> , 2008 ⁷⁰	None	Proportion of RHIOs sending and receiving data to different entities and proportion exchanging specific types of data	-Entity sending data -Entity receiving data -Type of data exchanged	NA	Survey
Adler-Milstein, Bates and Jha, 2009 ⁶⁷	None	RHIO exchanging data for ≥5,000 patients	-Types of data -Entities exchanging data -Sources of financial support	NA	Survey
Adler-Milstein, Landefeld and Jha, 2010 ⁶⁹	None	Factors associated with becoming operational and achieving partial or full financial viability	-Participation -Types of data exchanged, focused on a specific population, history of collaborating, and sources of revenue	NA	Multivariate logistic regression for predictors

Author, year	Results
Adler-Milstein, Bates and Jha, 2013 ²²	<p>Predominant organization nonprofit;</p> <p>Sources of support Grants and contracts: 52%; participant fees: 28%; operating costs not covered by revenue: 57%</p> <p>Barriers to development Sustainability: 74%; lack of funding: 57%; privacy: 60%; mandates: 55%; technical barriers: 61%; competition: 56%; linking; 54%</p>
Adler-Milstein, DesRoches and Jha, 2011 ⁹²	<p>10.7% participation in regional HIO; statistically significantly higher for private/nonprofit status, greater market bed share, teaching status, large size, cardiac ICU presence, and had EHR system</p>
Adler-Milstein, <i>et al.</i> , 2008 ⁷⁰	<p>Entities providing data Hospitals: 83%; ambulatory settings: 67%; labs: 60%; imaging results: 56%</p> <p>Entities receiving data Ambulatory settings: 95%; hospitals: 83%; public health departments: 50%; payers: 44%</p> <p>Type of data exchanged Test results: 90%; inpatient data test results: 90%; inpatient data: 70%; medication history: 70%; outpatient data: 60%</p>
Adler-Milstein, Bates and Jha, 2009 ⁶⁷	<p>Source of funding Time or in-kind resources: 64%; recurring fee: 55%; grant: 48%</p> <p>Types of data exchanged Test results: 84%; inpatient data: 70%; medication history: 66%; outpatient data: 64%</p> <p>28% of operational RHIOs expected to eventually cover operating costs</p> <p>Barriers Lack of funding, concerns about privacy/security, legal/regulatory changes, costs higher than expected, technical/infrastructure challenges</p>
Adler-Milstein, Landefeld and Jha, 2010 ⁶⁹	<p>Likelihood of being operational associated with exchanging narrow set of data and involving broad group of stakeholders, likelihood of financial viability associated with involvement of hospitals and ambulatory physicians and early funding from participants. Financial viability diminished with early grant funding.</p>

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Afilalo, <i>et al.</i> , 2007 ⁵⁸	Crossover cluster RCT	Impact of sending family physicians electronic vs. mailed reports of ED visits for their patients	Montreal, Canada	ED and family physician practices	Survey of family physician satisfaction	Not stated but likely same as Lang, 2006	Adult university teaching hospital in Montreal
Altman, <i>et al.</i> , 2012 ⁴⁹	Cross-sectional interviews of clinicians in a single health system that participated in the New York HIE	To assess clinicians' impressions of an hourly notification of ED visit, hospital admission or hospital discharge with respect to the notifications effect on the continuity and coordination of patient care	New York	Family practice clinics	Interviews	July 2011-October 2011	New York Clinical Information Exchange (NYCLIX)
Anand, <i>et al.</i> , 2012 ⁸¹	Survey of value for real-time alerting for patient ED visit anywhere in state	Is real-time alerting useful and does it lead physicians to take action?	Indiana	Primary care physician offices	Notification of patient visit to ED with letter that can be sent to patient for followup	June-November 2012	Indiana HIE (IHIE)
Audet, Squires and Doty, 2014 ⁹⁴	Analysis of Commonwealth Fund Health Policy Surveys	Measurement of physician exchange of data outside of practice or to receive hospital discharge reports	U.S.	Physician offices	Health policy surveys	March-July, 2012 (as well as comparison from data with 2009 survey, specific dates not provided)	All in U.S.

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Afilalo, <i>et al.</i> , 2007 ⁵⁸	Report of ED visit sent to family physicians	NR	Patients visiting ED during 0800-2200	2,022 (out of 3,168) patients visiting ED	Patients visiting ED	Patients in altered mental state (129), state of agitation (21), or with language barrier (29)
Altman, <i>et al.</i> , 2012 ⁴⁹	Hourly electronic notifications sent to family practice clinicians when any of 3 patient events occur at a participating hospital: (1) a new ED visit, (2) a hospital admission, or (3) a hospital discharge.	November 2010	Family practice clinicians receiving HIE notifications 86% MDs 50% male	14 of 20 total	Clinicians receiving notifications	None
Anand, <i>et al.</i> , 2012 ⁸¹	Patient data concerning ED visit	1994	Known physicians (538) of patients (1,275) seen in an ED for asthma	79 physicians (10%) receiving 126 (15%) notifications	Physicians who had ≥ 1 patient seen in ED and faxed notification letter back to HIE	NA
Audet, Squires and Doty, 2014 ⁹⁴	Physician exchange of data outside of practice or to receive hospital discharge reports	NA	1,012 primary care physicians in 2012	Various HIEs	Primary care physicians in U.S.	NA

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Afilalo, <i>et al.</i> , 2007 ⁵⁸	ED visit summary provided electronically vs. on paper sent by mail	Physician attitudes on aspects of continuity of care for patients	Survey	Physicians already are sent carbon copies of first page of ED note; self-report of followup data	Survey
Altman, <i>et al.</i> , 2012 ⁴⁹	Changes in practice as perceived by interviewee	Usage logs of number of notifications sent to each clinician over a period of several months, questionnaires	NA	NA	Themes of clinician perceptions identified and compared with recorded usage logs
Anand, <i>et al.</i> , 2012 ⁸¹	Information helpful, resulted followup action	Rates of information helpful, resulted in followup action	Survey	None	Survey
Audet, Squires and Doty, 2014 ⁹⁴	None	Proportion of physicians exchanging data outside of practice or receiving hospital discharge reports	Proportion of physicians exchanging data outside of practice or receiving hospital discharge reports	NA	Analysis of database

Author, year	Results
Afilalo, <i>et al.</i> , 2007 ⁵⁸	ED visits followed up by electronic reports led to family physicians having OR of higher rate of information receipt, more useful information, better knowledge of ED visits, better patient management, and more actions initiated by physicians. There was not perception of higher rate of followup in family practice offices.
Altman, <i>et al.</i> , 2012 ⁴⁹	Notifications from an HIE system can enhance clinicians' awareness of their patients' interactions in the medical system. Clinicians perceived improvements in communication and followup scheduling as a result of notifications. Increase in clinician workload and change in responsibility may be unintended effects of notifications Workflow issues should be carefully considered. Timely notifications may further improve clinician-to-clinician communication
Anand, <i>et al.</i> , 2012 ⁸¹	-35% found information helpful vs. 20% not helpful -24% made followup call to patient vs. 4% sent attached letter
Audet, Squires and Doty, 2014 ⁹⁴	32% use of HIE, with higher proportion for formal IT support, part of integrated system, receiving financial incentives, larger practice

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Bailey, <i>et al.</i> , 2013 ³¹	Longitudinal	To determine whether HIE by ED personnel in the evaluation of patients with headache reduces use of neuroimaging, increases adherence with guideline	Memphis, Tennessee	ED	Diagnostic neuroimaging, evidence-based guideline adherence	August 2007-July 2009	MidSouth e-Health Alliance (MSeHA).

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Bailey, <i>et al.</i> , 2013 ³¹	MSeHA HIE connects 15 major adult hospitals and 2 regional clinic systems in 4 counties of the Memphis Metropolitan Statistical Area. Patient demographic, diagnosis, all hospital radiologic and laboratory reports, most procedure reports, and discharge summaries are exchanged. ED providers have read-only access to data.	2007	Patients presenting to participating EDs with principle diagnosis of headache	2,101 2nd or subsequent visits for 1,252 patients	≥18 years, a second or subsequent ED visit to a MSeHA participating general hospital's ED between August 1, 2007 and July 31, 2009 with a primary discharge diagnosis of primary headache disorder (ICD-9-CM codes 346.0, 346.1, 346.9 and 784.0); and no discharge diagnosis of stroke (ICD-9-CM 430–438), brain cancer (ICD-9-CM 191.x, 225.0 and V10.85), traumatic injury, motor vehicle accident, poisoning, or fall.	Primary diagnosis (ICD-9 codes) of variants of migraine (346.2), hemiplegic migraine (346.3), chronic migraine (346.7), other forms of migraine (346.8), and tension headache (307.81, 339.1) 1st visit for headache

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Bailey, <i>et al.</i> , 2013 ³¹	None	Use of diagnostic neuroimaging (CT, CT angiography, MRI or MRI angiography), evidence-based guideline adherence and economic	-Any HIE use -HIE use by physician or nurse practitioner -HIE use by administrative/nursing staff	nonuse of HIE	Modeling using the generalized estimating equation method to adjust for repeated measures (since some subjects had >1 visit) and for clustering of subjects within hospital system

Author, year	Results
Bailey, <i>et al.</i> , 2013 ³¹	<p>OR (95% CI) of any HIE use</p> <p>Neuroimaging: 0.38 (0.29 to 0.50)</p> <p>Adherence to guideline: 1.33 (1.02 to 1.73)</p> <ul style="list-style-type: none"> -Increased odds of neuroimaging by subjects of older age, black race, and higher comorbidity -Prior visits lower the odds of imaging 7%, but the effect was reduced to 2% with use of HIE - No significant change in costs <p>Secondary analyses</p> <ul style="list-style-type: none"> -Administrative/nursing staff neuroimaging: OR 0.25 (95% CI, 0.18 to 0.34) -Physician/Nurse Practitioner HIE use and interaction terms for previous visits were not significantly associated -No secondary analyses were significant for guideline adherence

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Bailey, <i>et al.</i> , 2013 ³²	Longitudinal, Retrospective Cohort	To determine whether HIE reduces repeated diagnostic imaging and costs in ED back pain evaluation	Memphis, Tennessee	ED	Administrative data for imaging log in patient record for HIE access	August 2007-July 2009	MidSouth e-Health Alliance (MSeHA), 15 major hospitals and 2 regional clinic systems in the 4 most populous counties of the Memphis Metropolitan Statistical Area. Decentralized, query-based exchange. Consent was 'opt-out.

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Bailey, <i>et al.</i> , 2013 ³²	Secure, password-protected, read-only access to clinical information from participating hospitals and clinics through a Web portal separate from each facility's electronic health record system MSeHA HIE connects 15 major adult hospitals and 2 regional clinic systems in 4 counties of the Memphis Metropolitan Statistical Area. Patient demographic, diagnosis, all hospital radiologic and laboratory reports, most procedure reports, and discharge summaries are exchanged. ED providers have read-only access to data.	2007	All patients with an ED visit for back pain in the Alliance hospitals	Patients: 478 Visits: 800	≥18 years, >1 visit to system ED for back pain, index (previous visit) with imaging	Discharge diagnosis of trauma or cancer;

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Bailey, <i>et al.</i> , 2013 ³²	Repeat visits in which HIE was accessed vs. repeat visits in which HIE was not used	<ul style="list-style-type: none"> -Use of repeated lumbar or thoracic imagining -% cases HIE used -Cost 	<ul style="list-style-type: none"> -HIE accessed by any ED staff during repeat ED visit (Yes/No) -Type of staff accessing HIE (MD or Nurse Practitioner vs. admin or nursing) 	<ul style="list-style-type: none"> -Patient age, sex and race -Comorbidity -Hospital -Number of previous ED visits 	<ul style="list-style-type: none"> Chi² Multivariate: generalized estimating equation

Author, year	Results
Bailey, <i>et al.</i> , 2013 ³²	<p>Repeated imaging for any HIE: OR 0.36 (95% CI, 0.18 to 0.71), p<0.05</p> <p>Visits with repeated imaging: 22.4% (179/800)</p> <p>HIE used: 12.5%</p> <ul style="list-style-type: none"> -Physician or Nurse Practitioner use of HIE lowered OR for repeat imaging OR 0.47 (95% CI, 0.23 to 0.96) - No cost savings associated with HIE use because of increased CT imaging when health care providers used HIE

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Ben-Assuli, Shabtai and Leshno, 2013 ³³	Retrospective Cohort	To determine whether HIE use was associated with reduced readmissions and "avoidable" admissions	Main Israeli HMO network	7 acute care hospitals EDs belonging to largest Israeli HMO	Log-file	2004-2007	Largest Israeli HMO network 3.8 million patients, operates 7 hospitals
Bouhaddou, <i>et al.</i> , 2011 ⁷¹	Multi-site case study with focus on identification of patients eligible, matching, and consent; usage	Across 3 large integrated delivery systems, how many patients can and will participate; how much used	San Diego, California	Integrated delivery system	Patient identifier and demographic data	NR	Veterans Lifetime Electronic Record (VLER)

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Ben-Assuli, Shabtai and Leshno, 2013 ³³	Clinical and administrative data from all HMO hospitals, community clinics and thousands of labs, imaging centers etc. Demographics, prescriptions, allergies, lab, imaging, past medical history, procedures.	2004	Adult patients presenting to Israeli ED with 1 of 5 main diagnosis; gastroenteritis, abdominal pain, chest pain, pneumonia organism, urinary tract infection	115,719 ED Visits	NR	NR
Bouhaddou, <i>et al.</i> , 2011 ⁷¹	Query-based, transfer of records between integrated delivery systems	NR	Patients of 3 large IDSs who opted in to HIE	1,144 patients shared between VA and KP Nationwide Health Information Network allows users to pull in data from other organizations. The VA and DoD used the VLER systems for eHealth exchange with private sector. Federated pull (query-based) model Transfer of records between integrated delivery systems; National query-based. Patient consent: Opt-in.	Patients identified as getting care in VA and KP	None

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Ben-Assuli, Shabtai and Leshno, 2013 ³³	HIE vs. local EMR and no EMR HIE vs. local EMR use	<ul style="list-style-type: none"> -OR for 7-day readmission for gastroenteritis, abdominal pain, chest pain, pneumonia organism or urinary tract infection -OR for 1-day admission for gastroenteritis, abdominal pain, chest pain, pneumonia organism, or urinary tract infection -Economic 	<ul style="list-style-type: none"> -MD Viewed EMR -MD Viewed local EMR -MD viewed external information (HIE) -HMO to which patient belonged -Differential Diagnosis -ED sub department (Int. med or surgical) -Specific Hospital -Age -Gender -Authors list all these variables as independent but some are more confounding per se 	<ul style="list-style-type: none"> -Age -Gender -HMO -ED -Hospital 	<ul style="list-style-type: none"> -t test for continuous variables -Chi² for dichotomous -Multi-variate regression analysis -P<0.05, no adjustment for multiple hypothesis testing
Bouhaddou, <i>et al.</i> , 2011 ⁷¹	None	Patients who opted in and provided valid authorization, with subsequent measure of records exchanged between KP and VA 2-3 per week	<ul style="list-style-type: none"> -Patients correlated across KP and VA -Actual records exchanged 	NA	Survey

Author, year	Results
Ben-Assuli, Shabtai and Leshno, 2013 ³³	<p>OR for all 5 differential diagnosis as composite</p> <p>Readmission within 7 days: 0.52 for HIE vs. local EMR and no EMR, $p < 0.001$</p> <p>1-day admission: 0.76, $p < 0.001$</p> <p>Readmission within 7 days: 1.272, $p = 0.05$ for local EMR vs. HIE</p> <p>1-day admission: 1.13, $p = 0.005$ for local EMR vs. HIE</p> <ul style="list-style-type: none"> -Decrease in readmissions within 7 days when HIE used 56.1% -Decrease in single-day readmissions when HIE used 29.0% -Viewing external medical history more highly correlated with lower single-day admissions and 7-day readmissions than local medical history
Bouhaddou, <i>et al.</i> , 2011 ⁷¹	<p>Of 363 patients who opted in and provided valid authorization, 264 could be correlated; exchange of records between KP and VA 2-3 per week. Older patients were more likely to consent for HIE.</p>

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Byrne, <i>et al.</i> , 2014 ¹⁰¹	Mixed Methods: quantitative data on Veteran participation and provider usage, interviews with providers and Veterans	Describe key findings, lessons, implications from VLER pilot project	12 sites across U.S.	Unrestricted	Veterans authorization preferences, system dashboard, VA provider (11/12 site) and veteran interviews. 73 provider interviews, 50 veteran interviews	December 2009-October 2012	Veterans Lifetime Electronic Record (VLER)

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Byrne, <i>et al.</i> , 2014 ¹⁰¹	Query-based HIE between VA, DOD, nonfederal care organizations. The Nationwide Health Information Network. The VA and DoD used the VLER systems for eHealth exchange with private sector. Federated pull model transfer of records between integrated delivery systems; 12 total sites, 4 did 3 way exchange, 8 did 2 way between VA and private sector. Federated pull model via eHealth Exchange	December 2009	Veterans	12 pilot sites N=73 provider and 50 veteran interview	12 VLER pilot sites. Veterans included were any who opted in.	None

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Byrne, <i>et al.</i> , 2014 ¹⁰¹	NA	<ul style="list-style-type: none"> -Veterans accept -Veteran concerns about participation -Veterans perceived benefit -Veteran awareness of VLER use during their care -Veterans preference of signed authorizations -Metrics of exchanged data 	NA	NA	Descriptive Stats

Author, year	Results
Byrne, <i>et al.</i> , 2014 ¹⁰¹	<ul style="list-style-type: none"> -64,237 veterans provided authorization and opted in -Opted in then out: <0.01% -Veterans matched with exchange partner: 31,080 (48%), range: 12-88% -Highest matching rates with exchange partners using social security number in their algorithm -Inbound discloser's to VA from exchange partners 5,524 -Outbound disclosure to exchange partner 13,913 -Inbound disclosures to VA from exchanged partners per matched patients 18/100 -Unique VA patient with exchange partner data retrieved: 2,724 -Unique VA providers retrieving exchange partner data: 1,764 - Percent of matched veterans for whom there was ≥1 disclosure to VA from exchange partner: 9% -75% of providers trusted VLER data, 90% trusted privacy and security -Most frequently cited provider benefits, more data for medical decision making, improved quality of care, reduced repeat testing, timelier and faster access to information -23/73 interviewed providers reported using VLER, 79% of users reporting overall satisfaction -43% reported challenges with system response time, 29% with identifying patients who might have data -Identified minimizing provider steps in information retrieval, one site Indiana HIE had an automated query resulting in push into their system to allow providers pushed access anytime a patient was admitted discharged or transferred -Providers at outside organizations did not having additional sign ones -Workflow improvements suggested by outside users was to have data pushed in their EMR -Sustaining HIE requires ongoing resources and oversight, often unanticipated technical issues arose -Requires national policies and central coordination -None of the veterans interviewed were aware if their providers were using HIE, the user-interfaces at the sites face the provider not the patient -Providers increased usage after training on VLER system -Providers noted barriers of missing data, additional sign-on and need for better integration with workflow

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Campion, <i>et al.</i> , 2013 ⁸³	Cross-sectional	Determine the extent to which automated HIE queries supported patient encounters.	Binghamton, New York	Hospital/clinic	HIE log data	2010 until 23 months following	Southern Tier HealthLink RHIO in Binghamton, New York part of SHIN-NY. Automated queries occurred evening prior to ambulatory patient appointments to generate CCRs and for the hospitals during ED visits, at inpatient admission, inpatient unit transfer and provided CCD doc to providers. Providers could also log in manually. Auto queries started month 1 for clinics and month 17 for hospitals.
Campion, <i>et al.</i> , 2012 ⁵⁰	Cross-sectional survey of satisfaction with push vs. pull HIE	What is usage and satisfaction of push and pull HIE	Buffalo and Rochester, New York	Health systems, health departments, practice associations, RHIO	Online survey responses from 112/584 invited physicians (19% response rate)	July-December 2010	HealthLINK (Buffalo) and Rochester RHIO

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Campion, <i>et al.</i> , 2013 ⁸³	Lawson Cloverleaf HIE, centralized data repository with MPI. 5 hospitals, one imaging center and 30 ambulatory care practices affiliated with single integrated delivery system.	2005	≥18 years, with positive consent to participate in HIE	202,365 auto queries	≥18 years, who had automated HIE query generated, which occurred when a care transition occurred	Lack of known provider or lack of known facility in auto-queries from HIE
Campion, <i>et al.</i> , 2012 ⁵⁰	Direct exchange (push) of local lab and radiology results; query-based (pull) searching for lab and radiology results across greater Buffalo and Rochester area. Robust RHIOs using HIE platform from Axolotl Corporation (San Jose, California)	2007-2009	Physicians	112/584 invited physicians (19% response rate). Only 99 completed. 75% were primary care providers. Most practices had 2-19 providers.	Physicians who completed survey and rated overall outcome of satisfaction with HIE	Respondents who did not rate satisfaction with HIE

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Campion, <i>et al.</i> , 2013 ⁸³	NA	Generation of automated HIE queries	NA	NA	Descriptive Stats
Campion, <i>et al.</i> , 2012 ⁵⁰	Compared various attributes of HIE for push vs. pull	Use of push vs. pull HIE. Satisfaction with types of HIE.	Type of HIE: push or pull	NR	Survey

Author, year	Results
Campion, <i>et al.</i> , 2013 ⁸³	<p>-202,365 automated HIE queries: 54% to hospitals, 46% to clinics</p> <p>-After exclusions, duplicates removed: 145,668 unique patient encounters</p> <p>-81,687 unique patients provided consent for query based HIE during study period, 41% had ≥1 supported encounter</p> <p>-For the 33,219 patient with ≥1 clinic encounter: median IQR 3</p> <p>-98% of patients had between 1 and 20 encounters, 71% had ≥2</p> <p>-530 patients with ≥20 encounters</p> <p>-52% occurred in hospital, 48% in clinics</p> <p>Care Transitions</p> <p>-28% of the 145,668 unique encounters occurred as care transitions</p> <p>-53% were patients from a clinic to hospital, 36% in reverse, 11% clinic to clinic</p>
Campion, <i>et al.</i> , 2012 ⁵⁰	<p>-80% used push HIE and 53% used pull HIE</p> <p>-A greater proportion of MDs reported using push HIE always or most of the time (68%) vs. pull HIE (19%), p=0.001</p> <p>-MDs more satisfied with push HIE vs. pull HIE, p<.0.05</p> <p>-112 physician respondents (19% response), 13 then excluded for 99 participants</p> <p>->50% of physicians felt HIE improved 8 domains; access to timely, completeness, accurate information, admin efficiency, communication with colleagues, and quality</p> <p>-Only 30% felt it improved reducing test redundancy and security of PHI</p> <p>-Physicians who used push and pull vs. only single type had higher rates of perceived effects of HIE in same 8 domains, (3of 8 domains p<0.05)</p>

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Campion, <i>et al.</i> , 2013 ⁸²	Cross-sectional survey	Measure usage patterns of query based HIE with respect to practice sites, users, patients, and data	3 separate RHIOs encompassing 1 community each (~1 million patient population) in New York state (from HEAL-NY)	Unclear, inpatient/ outpatient	System log data, demographics of patient, provider character (i.e. role, location etc.)	A, B: January 2009-March 2011 C: September 2010-May 2011	NY State HIE consists of 12 RHIOs (HEAL NY)
Carr, et al., 2014 ⁶²	Self-report of testing avoided resulting from data in HIE	Does HIE reduce unneeded test ordering and costs, admissions	Charleston, South Carolina	ED	User-initiated survey, with costs calculated for self-reported testing not performed	August-December 2011	Carolina eHealth Alliance
Chang, <i>et al.</i> , 2010 ⁵¹	Evaluation of system output, Cross Sectional Survey	Development and evaluation of enhanced reporting of lab data based on date available to HIE	Indiana	Physician office, outpatient	Survey of physicians who were potential users of reporting interface	2 week period in 2007	Indiana Network for Patient Care

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Campion, <i>et al.</i> , 2013 ⁸²	Axolotl Virtual Health Record-commercial product. Web based secure stand alone portal. Federated architecture with MPI, RLS and user directory.	2007, 2007, 2010; A,B and C, respectively.	All patients	Combined 2.9 million total patients in 3 RHIO communities	All patients	None
Carr, et al., 2014 ⁶²	Access to EHRs and ED from all hospitals in region	NR	Physicians, Nurse Practitioners, Physician Assistants, and students	18,529 patient encounters, with 998 logons (5.39%) by 60 clinicians. 138 (13.8%) surveys completed. 105 (10.5%) of patients had data in HIE.	All survey responses from HIE users	NA
Chang, <i>et al.</i> , 2010 ⁵¹	Collection of all lab data with enhancements (prior results, other historical lab results, prescriptions, encounters), pharmacy data, and patient encounter data	Not stated, but in 1990s	Primary care physicians who were users of HIE	NA	Convenience sample of primary care physicians	NA

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Campion, <i>et al.</i> , 2013 ⁸²	NA	<ul style="list-style-type: none"> -% practice sites accessing data -Type of practice accessing HIE -Number of roles and primary practice of users accessing HIE -Characteristics of patients whose data was accessed -Consenting of patients related to access 	NA	NA	Descriptive Stats
Carr, et al., 2014 ⁶²	None	<ul style="list-style-type: none"> -Services, costs, and admissions avoided -Perceived time saved 	Tests, costs, and admissions avoided	NA	Self-reported tests and admissions avoided, calculation of costs saved based on local data.
Chang, <i>et al.</i> , 2010 ⁵¹	None	Evaluation of developed report	Various factors related to usefulness and completeness	NA	Satisfaction survey

Author, year	Results
Campion, <i>et al.</i> , 2013 ⁸²	<p>A vs. B vs. C</p> <ul style="list-style-type: none"> -Of sites registered to use system: 18% vs. 30% vs. 82% accessed in first 9 months -After 27 months 60% vs. 59% vs. NR of sites had accessed -In each community majority of practice sites from which access occurred were out patient -In A and B majority of sessions were from out patient sites, C was inpatient -Registered users in community: 368 vs. 3461 vs. 118 -More than 1/2 users accessing system in A and B were nurses + staff, in C 2/3 were MDs + physician extenders -Majority of all users practiced in ambulatory setting -Patients whose data was accessed were older than those whose was not and than the entire population -For community A&B majority had data accessed on same day as consent -Majority of patients in A and B had their data accessed in community setting, C was inpatient -% of patient whose data was accessed from ≥ 2 sites in first 9 months: 0.1% vs. 1.8% vs. 0.01%; after 27 months: 0.1% vs. 11.6% vs. NR -System access occurred from 60% to 82% of practice sites registered to use system, depending on community -Proportions of patients whose data were accessed varied between 5%-60% -Most frequently accessed data were patient summaries, followed by lab and radiology data
Carr, <i>et al.</i> , 2014 ⁶²	<ul style="list-style-type: none"> -Reported avoiding: 30.5% lab/micro tests (\$462), 47.6% radiology tests (\$161,000), 19% consultations (\$4,000), 11.4% admissions (\$118,000) -86.7% reported improved quality of care -81% reported time savings, averaging 120.8 minutes
Chang, <i>et al.</i> , 2010 ⁵¹	<ul style="list-style-type: none"> -9 physicians sampled -Average 5 point Likert scales reported showed perception was generally favorable. ELRs well organized (4.2\pm0.97) and easy to interpret (4.3\pm0.50). Additional data elements were valuable: relevant test (4.2\pm0.97), contextual drugs (4\pm0.89), visit histories (3.25\pm0.71) and computer generated clinical reminders (3.25\pm0.71). Compared with traditional lab results ELRs generally saved time (3.78\pm0.67), reduce the need to search for information (3.67\pm0.71) and improve quality of care (3.78\pm0.67). Physicians asked whether they would prefer to use ELRs instead of traditional reports (3.78\pm0.67).

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Dixon, Miller and Overhage, 2013 ¹³⁹	Survey of participation of small hospitals, small physician practices, and large physician practices not participating in a mature state HIE	What are barriers to participation in a mature state HIE?	Indiana	Small hospitals, small physician practices, and large physician practices	Initial mixed methods interviews with most physician groups given online survey	August 2009-March 2010	Indiana HIE (IHIE)
Dixon, Jones and Grannis, 2013 ⁷²	Online survey	Awareness and engagement of infection preventionists in HIE for public health surveillance	6 states with HIE - 3 funded by CDC for explicit HIE-based reporting and three with mature HIEs	Case reporting for public health reporting of notifiable conditions	Online survey of 63 infection preventionists	NR	6 states with mature HIEs but details not explicitly provided
Dixon, McGowan and Grannis, 2011 ³⁴	Data quality assessment	To determine completeness of data for public health electronic laboratory reporting in an HIE	Indiana	Public health	-7.5 lab results reported in HIE -Statutory public health reporting records	November 14, 2010-December 15, 2010	Indiana HIE (IHIE)- includes lab reports

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Dixon, Miller and Overhage, 2013 ¹³⁹	Full medical record in HIE	1994	Small hospitals, small physician practices, and large physician practices in Indiana who were not participating in HIE	12 small hospitals, 20 small physician practices, and 11 large physician practices who were not participating in HIE	Small hospitals, small physician practices, and large physician practices in Indiana who were not participating in HIE	Small hospitals, small physician practices, and large physician practices in Indiana who were not participating in HIE
Dixon, Jones and Grannis, 2013 ⁷²	6 states with HIE — 3 funded by CDC for explicit HIE-based public health surveillance reporting for infections, versus three with mature HIEs, but without active surveillance reporting. 63 preventionists.	Not specific, would be variable by state	Infection preventionists	NA	Infection preventionists in public health departments in 6 states	NA
Dixon, McGowan and Grannis, 2011 ³⁴	Reporting of all lab data	NR, but in 1990s	All patients having lab tests	7.6 million lab reports from 168 hospitals and lab information systems, of which 16,365 from 49 hospitals and lab information systems were enhanced by a Notifiable Condition Reporter	All laboratory values	NA

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Dixon, Miller and Overhage, 2013 ¹³⁹	Barriers of cost, lack of sufficient technical or human resources, or lack of awareness regarding value proposition	Barriers of cost, lack of sufficient technical or human resources, or lack of awareness regarding value proposition	Survey	None	Qualitative content analysis of interviews and quantitative tabulation of surveys
Dixon, Jones and Grannis, 2013 ⁷²	Comparisons in states with active public health surveillance vs. those without	-EHR use -EHR involvement in implementation -Involvement in HIE -Method for notifiable case reporting	-Organizations with EHR -Involved in implementation of EHR -Engaged in HIE -Reporting methods for notifiable cases	NA	Survey
Dixon, McGowan and Grannis, 2011 ³⁴	Proportion of fields in lab reports that were complete	Comparison of completeness of lab test results for regular and enhanced systems	19 data elements	NA	Completeness of data fields

Author, year	Results
Dixon, Miller and Overhage, 2013 ¹³⁹	<p>Barriers (small hospitals, small physician practices, large physician practices)</p> <p>Cost: 100%, 50%, 55%</p> <p>Lack of sufficient technical or human resources: 42%, 45%, 36%</p> <p>Lack of awareness regarding value proposition: 33%, 15%, 36%</p>
Dixon, Jones and Grannis, 2013 ⁷²	<p>-72% in organizations with EHR; 20% involved in implementation of EHR; 10% engaged in HIE; 49% unaware of organizational involvement in HIE</p> <p>-<5% reporting via secure email, web-based entry, through EHR, or through HIE each</p>
Dixon, McGowan and Grannis, 2011 ³⁴	<p>-Patient identifiers and test, name, and results were nearly 100% complete for both; most but not all measures more complete for enhanced system</p> <p>-15 of 18 record fields showed improved completeness with enhanced system. Units of measure, normal range and abnormal flag fields all showed reduced completeness with enhanced system. No tests of statistical significance performed.</p>

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Dobalian, <i>et al.</i> , 2012 ¹¹⁸	Qualitative	Describe lessons learned from one Nationwide Health Information Network implementation	Long Beach, California	3 hospitals, 2 ambulatory practice groups	Test data	2008	One site in Nationwide Health Information Network , Used First Gateways exchange (HealthView). This specific HIE was called Long Beach Network for Health

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Dobalian, <i>et al.</i> , 2012 ¹¹⁸	Make inpatient and outpatient data available to ED. Were not yet able to exchange data about patient care.	2008	ED patients	N=18 to sample	NR	NR

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding	Analysis Methods
Dobalian, <i>et al.</i> , 2012 ¹¹⁸	Participants in LBNH vs. not in LBNH	Descriptive narrative only	NA	NA	NA

Author, year	Results
Dobalian, et al, 2012 ¹¹⁸	"Despite a limited concentration on ED care, virtually all respondents noted concerns regarding the sustainability, or business case, for the exchange of health information."

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Dullabh and Hovey, 2013 ¹²⁹	Qualitative	1) Assess the experience of states in establishing governance structures, technical services to enable health information exchange, and privacy and security frameworks; 2) Assess stakeholder priorities, current use, and anticipated need for information exchange; 3) Identify common enablers, barriers, and challenges; and 4) Collect and characterize lessons learned.	Maine, Nebraska, Texas, Washington, Wisconsin	Health Systems, provider association, state health IT coordinators, state public health agencies	Not clearly stated but suggests: lab exchange, e-prescribing and exchanging clinical care documents.	November 29, 2011 - March 21, 2012	Not described per state
Fairbrother, <i>et al.</i> , 2014 ¹¹⁹	Quantitative	Describe the Beacon community program experience	Greater Cincinnati area, Ohio	Primary care, hospitals, federally qualified health centers and community centers insurance partners	Alerts for diabetic and pediatric asthma patients in ED or admitted sent to primary care.	Fall 2012	87 primary care, 18 hospital, 7 federally qualified health centers and community centers, 3 insurance partners

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Dullabh and Hovey, 2013 ¹²⁹	States had two models of HIE: "thin layer" model with services based on light infrastructure (Texas, Washington and Wisconsin), or a heavy infrastructure model (Nebraska and Maine) with features such as a central repository"	NR	NR	N=105 to sample; no response rate reported.	NR	NR
Fairbrother, <i>et al.</i> , 2014 ¹¹⁹	Data exchange, registries, alerts to PC practices when patient in ED or admitted to hospital.	September 1, 2010 - March 31, 2013	Adult diabetics, pediatric asthma patients	N=38 interviews to sample	Adult diabetics, pediatric asthma patients	NR

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Dullabh and Hovey, 2013 ¹²⁹	Comparison of 5 states	Descriptive narrative only	NA	NA	NA
Fairbrother, <i>et al.</i> , 2014 ¹¹⁹	NA	Descriptive narrative only	NA	NA	NA

Author, year	Results
Dullabh and Hovey, 2013 ¹²⁹	"Results show the last 2 years have seen unprecedented growth in HIE infrastructure. Key factors such as maturity of HIE at baseline and healthcare market characteristics have shaped governance models and technical infrastructures." "Given the significant concerns about sustainability and who will pay for state-offered services in the long term, it may also prove beneficial to ensure that states have assistance, either from state or national informational resources, in developing both sustainability plans and contingency plans."
Fairbrother, <i>et al.</i> , 2014 ¹¹⁹	Despite some setbacks and delays, the basic technology infrastructure was built, the alert system was implemented, 19 practices focusing on diabetes improvement were recognized as patient-centered medical homes, and many participants agreed that the program had helped transform care.

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Feldman and Horan, 2011 ³⁵	Semi-structured interviews	To determine challenges and successes of HIE for Social Security disability determination	Virginia	SSA, MedVirginia HIE, and Bon Secours Health System	Interviews of 43 individuals from the 3 participating organizations	June-November 2009	Medical Evidence Gathering Through Health IT (MEGAHIT)
Feldman, Schooley and Bhavsar, 2014 ¹³⁰	Case study	Obtain insights into technical, organizational, and governance issues of a large private health system participating in a state HIE	Virginia	Integrated delivery system	Direct observation, informal information gathering, document analysis, and semi-structured interviews	August 2012-June 2013	ConnectVirginia EXCHANGE
Foldy, 2007 ⁷³	Cross-sectional survey	Description of projects, stages, users, organizational home, governance, scope, standards, drivers, challenges, recommendations	Wisconsin	Any	Survey, unable to access due to broken URL link	2006	NA

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Feldman and Horan, 2011 ³⁵	Data for Social Security disability determination transmitted from health system through HIE to SSA via NHIN, push of background, lab, and medication data in a CCD from health system to SSA	February 2008	Patients being evaluated for Social Security disability determination; interviewed included personnel from the 3 participating organizations	203	Members of 3 organizations	NA
Feldman, Schooley and Bhavsar, 2014 ¹³⁰	Query of Continuity of Care Documents	August 2012	All patients in Invoa IDS	10 individuals from IDS, HIE, and vendors	Members of all organizations	None
Foldy, 2007 ⁷³	HIE defined as projects in which multiple independent organizations routinely send or receive electronic clinical information about patients for purposes other than billing or claims payment	NA	eHealth board, staff, consultants, workgroup members and survey respondents all nominated the survey recipients	30 Organizations contacted, 27 (90%) responded	eHealth board, staff, consultants, workgroup members and survey respondents all nominated the survey recipients	NR

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Feldman and Horan, 2011 ³⁵	None	Technical, organizational, and governance attributes	Mean Social Security disability case processing time 59 days (vs. average of 84)	NA	Development of Collaborative Enactment Model
Feldman, Schooley and Bhavsar, 2014 ¹³⁰	None	Technical, organizational, and governmental attributes	NA	NA	Themes extracted from data
Foldy, 2007 ⁷³	NA	<ul style="list-style-type: none"> -Status of projects operation vs. planned -Stage of development -Description of information users -Organization, funding, governance -Scope -Standards -Drivers -Challenges -Recommendations 	NA	NA	Descriptive Stats

Author, year	Results
Feldman and Horan, 2011 ³⁵	<p>-Technical challenges of HIE can be overcome but organizational and governance factors are also important</p> <p>30% decrease in mean case processing time from 84 to 59 days from the usual method to HIE supported method, respectively.</p>
Feldman, Schooley and Bhavsar, 2014 ¹³⁰	<p>Some technical challenges required workarounds, leadership and adequate resources essential, and appropriate decision making authority required</p>
Foldy, 2007 ⁷³	<ul style="list-style-type: none"> -27 responded, 21 judged to be HIE organizations, 21 respondents had 16 operational projects, 11 planned projects -Rating of most advanced HIE project had 40% of respondents in implementation and 40% in operational -44% deliver data only to central registries, 50% deliver to providers and registries and only 1 to providers only -62.5% are based in government organizations -73% started with only public funds, 20% exclusively private, 7% used both -For continued operations 57% rely entirely on public funds, 21% only on private and 21% a combo -Governance all have multiple stakeholders -14 are statewide, 7 southeast Wisconsin, 2 south, central and north and west. -Standards 46% of projects have specific vocabulary or data standards

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Fontaine, <i>et al.</i> , 2010 ⁷⁴	Questionnaires and interviews	Examine factors that motivate or prevent small primary care practices from participating in EHR and HIE use as mandated by Minnesota e-Health Law from 2007	Minnesota	Primary care practices with <20 providers in 1 of the 3 described HIE regions	NA	November 10, 2008-February 20, 2009	Various HIEs
Frisse, <i>et al.</i> , 2012 ³⁶	Cross-sectional	To examine the financial impact of HIE in EDs	Memphis, Tennessee	ED	Tennessee Hospital Association billing database of all ED visit records	January 2007-December 2008	MidSouth e-Health Alliance (MSeHA)

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Fontaine, <i>et al.</i> , 2010 ⁷⁴	9 primary care practices in Minnesota 3 HIE initiatives in Minnesota 1) a 10 year old HIO that promotes HIE and coordinates immunization registry, 2) network of independent metropolitan community clinics that received MN e-health grant funding to implement EHRs, 3) initiative to develop PHR with congestive heart failure patients	NR	39 participants in discussions	Unclear	NA	NA
Frisse, <i>et al.</i> , 2012 ³⁶	11 of 12 hospitals accessed information through a dedicated secure web portal. 1 hospital printed encounter summaries as part of triage for the first 10 months of the study. Patient demographic, diagnosis, all hospital radiologic and laboratory reports, most procedure reports, and discharge summaries are exchanged.	2005	All ED visits	15,798 visits in which HIE was accessed; matched comparison group of 15,798 cases	ED visit to 1 of the participating hospitals. Visit only in HIE or no HIE subset.	Patients in both the HIE and no HIE subset (932) HIE accessed in non ED setting (3,555)

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Fontaine, <i>et al.</i> , 2010 ⁷⁴	NA	<ul style="list-style-type: none"> -Use of EHR -What data elements are being sent/received 	NA	NA	Descriptive
Frisse, <i>et al.</i> , 2012 ³⁶	Encounters with vs. without HIE	<ul style="list-style-type: none"> -Financial consequences based on ED-originated hospital admissions -Admissions for observation, lab tests, head or body CT, ankle or chest radiographs, echocardiograms 	HIE accessed during ED visit	<ul style="list-style-type: none"> -Admission type -Length of stay -Charlson comorbidity index -Patients matched on age, gender, race, site of ED, diagnosis and payer 	Generalized estimating equation logistic regression

Author, year	Results
Fontaine, <i>et al.</i> , 2010 ⁷⁴	<p>-8/9 practices uses EHR</p> <p>-Only 1 practice was able to transmit/receive patient health records</p> <p>-All 9 practices shared information with department of health immunization registry though not through any of the EHRs in the practices</p> <p>-Labs were next most common Several practices were receiving data directly into EHRs</p> <p>-None were sharing data with nonaffiliated practices</p> <p>-HIE motivations themes: External - government mandates, payer mandates, quality reporting; Internal - cost savings, quality/patient safety, efficiency</p> <p>-HIE barriers: lack of interoperability, lack of buy-in, competition, security, costs, creating business model, limited success and large time investment, limited technical support</p> <p>-No practice was fully involved in a regional HIE; HIE was not part of most practices' short-term strategic plans.</p>
Frisse, <i>et al.</i> , 2012 ³⁶	<p>HIE accessed: 6.8% of ED visits (in 12 EDs)</p> <p>Admissions when HIE used</p> <p>Adjusted OR 0.27; 95% CI, 0.210 to 0.351, p<0.0001</p> <p>191 fewer admissions with HIE vs. without HIE</p> <p>-In 11 EDs directly accessing HIE data only through a secure Web browser, access was associated with a decrease in hospital admissions (adjusted OR 0.27; p<0001)</p> <p>-In 12th ED relying on print summaries, HIE access was associated with a decrease in hospital admissions (OR 0.48; p<0001) and statistically significant decreases in head CT use, body CT use, and laboratory test ordering</p> <p>-HIE access associated with annual cost savings of \$1.9 million, with hospital admission reductions accounting for 97.6% of total cost reductions</p>

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Furukawa, <i>et al.</i> , 2013 ⁹⁶	Survey	Describe extent of HIE in U.S. hospitals	All 50 states and the District of Columbia	Hospital	Health IT supplements to the American Hospital Association Annual survey of hospitals, 2008-2012. 63% response rates. 2,805 hospitals in 2008, 2,836 hospitals in 2012. nonfederal acute care hospitals	2008-2012	NA
Furukawa, <i>et al.</i> , 2014 ⁹⁵	Qualitative and descriptive	NAMCS Survey, How have rates of EHR changed since HITECH? What % of MDs are engaged in HIE in 2013? What % are using PHR in 2013? How did these things vary by physician and practice characteristics?	U.S.	U.S. ambulatory providers	NAMCS CDC 2009 EHR supplement 2009-2013	2009-2013	NA
Gadd, <i>et al.</i> , 2011 ⁷⁵	Cross-sectional survey	To assess the usability of an HIE in a densely populated metropolitan region	3 counties around Memphis, Tennessee	ED and out patient clinics	Email survey responses from 165/ 237 health care professionals (70% response rate)	June-November 2009	MidSouth e-Health Alliance (MSeHA) A rapid deployment HIE that consolidated data from several sources
Genes, <i>et al.</i> , 2011 ¹²⁰	Semi-structured interviews of ED HIE users	What are perceptions of ED users of HIE?	New York City	ED	Semi-structured interviews of users and nonusers	NR	New York Clinical Information Exchange (NYCLIX)

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Furukawa, <i>et al.</i> , 2013 ⁹⁶	NA	NA	U.S. acute care nonfederal hospitals	2,805 hospitals in 2008 and 2,836 in 2012 Various HIEs	NA	NA
Furukawa, <i>et al.</i> , 2014 ⁹⁵	NA	NA	Ambulatory physicians not radiologists, pathology, or anesthesia	NR	NA	NA
Gadd, <i>et al.</i> , 2011 ⁷⁵	Consolidated data from multiple hospital EDs and community-based ambulatory clinics. Decentralized, query-based exchange. Consent was opt-out.	2004 in 3 counties	Medical staff (Physicians, Nurse Practitioners, Physicians assistants, nurses, and other) at organizations participating in the HIE	162 responses analyzed Details on sample: 345 people identified; 269 valid contacts; 237 surveys distributed; 165 responses (69.6%); 3 excluded for missing responses on satisfaction items.	NR other than list of roles included	People who were no longer employed by the system were not contacted
Genes, <i>et al.</i> , 2011 ¹²⁰	All data from 10 academic medical centers	2009	ED physicians	18 users of NYCLIX ED pilot	All users	NA

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Furukawa, <i>et al.</i> , 2013 ⁹⁶	NA	Any exchange activity with outside providers outside the organizations	NA	-Provider type -Organizational affiliation -Type of clinical information -Hospital characteristics -Area characteristics	T test
Furukawa, <i>et al.</i> , 2014 ⁹⁵	NA	Descriptive statistics	NA	NA	Descriptive Stats
Gadd, <i>et al.</i> , 2011 ⁷⁵	The impact of usability on use of HIE	-Use -Questionnaire for User Interaction Satisfaction (QUIS 7.0) -Trust	None	None	-Wilcoxon rank sum test -Descriptive statistics -Ordinal logistic regression
Genes, <i>et al.</i> , 2011 ¹²⁰	-For users, was HIE data useful? -For nonusers, why not using?	-For users, was HIE data useful? -For nonusers, why not using?	Semi-structured interviews	None	Semi-structured interviews

Author, year	Results
Furukawa, <i>et al.</i> , 2013 ⁹⁶	<p>-58% of hospitals exchanging in 2012, 41% increase of 2008, $p < 0.01$</p> <p>-2012 51% hospitals exchanged with unaffiliated ambulatory providers, 36% with other hospitals outside their organization</p> <p>-2012 52%, 53%, 35% and 33% exchanging radiology reports, labs, care summaries and prescription lists with outside providers, respectively. That is a 39%, 51%, 40%, 55% increase, respectively.</p> <p>-After adjusting for hospital and area characteristics hospitals with basic EHR and participation in Health information organizations had highest rates of exchange activity in 2012, 80% of hospital with EHR and HIO were exchanging, 71% with HIO but no EHR were exchanging 60% of hospitals with EHR but no HIO were exchanging, all consistent across different providers types and clinical information types</p> <p>-Hospital characteristics associated with lower exchange rates, rural, for-profit, locations with greater Medicare part A spending</p>
Furukawa, <i>et al.</i> , 2014 ⁹⁵	<p>-Broad HIE definition (39% of office-based physicians reported having an HIE with other providers or hospitals). Increased odds of HIE both within and outside of their organization with larger practice, health-system owned practice and multispecialty practice. Very few characteristics associated with HIE outside of the practice, significantly lower outside HIE with community health centers and practice outside of metropolitan statistical centers</p> <p>-35 % HIE inside, and 13% HIE outside</p>
Gadd, <i>et al.</i> , 2011 ⁷⁵	<p>151 users (93%), 11 non users</p> <p>Average usage per week</p> <p><1 hour: 65 (43%)</p> <p>1 hour to <4 hours: 58 (39%)</p> <p>≥4 hours: 27 (18%)</p> <p>Mean usability scale: 6.5 SD 1.4 (>5 is favorable, out of 9)</p> <p>Association of Scales with higher use (ORs)</p> <p>Overall reactions: 1.50, $p < 0.01$</p> <p>Learning: 1.32, $p < 0.05$</p> <p>System functionality: 1.34, $p < 0.01$</p> <p>Trust not predictive of usage. Users commented that HIE needs more tech support and could use more types of data</p>
Genes, <i>et al.</i> , 2011 ¹²⁰	<p>-Half of users reported usage affecting patient care on ≥1 occasion</p> <p>-nonusers reporting forgotten login credentials</p>

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Goldwater, <i>et al.</i> , 2014 ¹³¹	Mixed	Evaluate the progress of the HIE, how many providers and hospitals were participating in the program, and what benefits were being realized through the use of the HIE.	Washington, District of Columbia	6 acute care hospitals	Demographic, inpatient, encounter notifications, lab testing, electronic prescribing services, integration with public health and Medicaid providers.	July 1, 2013-January 6, 2014. Survey of 148 individuals and stakeholders released October 1, 2013 and closed November 4, 2013.	The 6 acute care hospitals chose the Chesapeake Regional Information System for our Patients
Grossman, Kushner and November, 2008 ¹²¹	Interviews with stakeholders in 4 HIEs: 2 mature and 2 newer	Compare differences in success and barriers for HIEs	Indiana, Cincinnati, Northeast Tennessee, Tampa Bay	Any	Interviews of stakeholders	February-August 2007	IHIE, HealthBridge, CareSpark, Tampa Bay RHIO
Gutteridge, <i>et al.</i> , 2014 ⁹⁷	Descriptive	To describe the development and use of a CEN system based on an HIE.	New York metropolitan are	ED, hospital, and outpatient	Subscription lists and reports generated	March 11, 2013-March 2, 2014	Healthix

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Goldwater, <i>et al.</i> , 2014 ¹³¹	Demographic, inpatient, encounter notifications, lab testing, electronic prescribing services, Integration with public health and Medicaid providers.	Launched February 2012	Survey sent to 148, 30 completed 20% response rate	NR	NR	NR
Grossman, Kushner and November, 2008 ¹²¹	All types	Varying	Stakeholders in 4 HIEs	NA	NA	None
Gutteridge, <i>et al.</i> , 2014 ⁹⁷	A federated architecture for data sharing. Log in is via a stand alone web portal -Healthix included a total of 107 organizations with 383 facilities, 9.2 million patients, and >6,500 users performing >10,000 patient searches per month as of January 2014	2004 was initial funding CEN system March 2013	Geriatric patients seen in ED and admitted to hospitals	These patient who are enrolled in the system	NA	NA

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Goldwater, <i>et al.</i> , 2014 ¹³¹	NA	Descriptive narrative only	NA	NA	NA
Grossman, Kushner and November, 2008 ¹²¹	None	Success, barriers, sustainability	NA	NA	Interviews
Gutteridge, <i>et al.</i> , 2014 ⁹⁷	None	-Enrollment of patients -Number of notifications sent	NA	NA	Counts

Author, year	Results
Goldwater, <i>et al.</i> , 2014 ¹³¹	"HIE is used to electronically capture and report immunization data; and in requiring electronic lab reporting and results as part of the Meaningful Use Requirement—which can assist in detecting HIV/AIDS and providing better care for the district's high population of individuals with HIV/AIDS. Electronic lab reporting and electronic prescribing within the HIE can assist the Department of Health and providers in identifying specific diseases, such as tuberculosis and viral hepatitis, before they affect a significant part of the population. "
Grossman, Kushner and November, 2008 ¹²¹	Stakeholder buy-in essential for success, offering hospitals value to reduce costs important, hospitals concerned about controlling access to data, employers and health plans not buying in
Gutteridge, <i>et al.</i> , 2014 ⁹⁷	<ul style="list-style-type: none"> -5,722 patients enrolled (612 notifications sent) -Without duplications 497 event notifications about 206 unique patients -Notifications originated from 23 separate institutions, ED visits comprised 44% (219 of the 497 notifications), 98 notifications were for inpatient admissions -121 of 497 (55%) during normal business hours -Hospital admissions resulted from 45% of ED visits; 17.8% of these lasted <48 hours, suggesting they were avoidable -70% of notifications were received within 1 hour of the event, during the study year; in following year 71% were received within 15 minutes

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Hamann and Bezboruah, 2013 ⁹⁸	Secondary analysis of cross-sectional survey	To examine ownership differences (for-profit; non profit) in the use of technology in long term care facilities	U.S.	Nursing homes and residential care	2004 National Nursing Home Survey; 2010 National Survey of Residential Care Facilities	Nursing home: August 2004-January 2005 Residential care: 2010	Varies, NR
Herwehe, <i>et al.</i> , 2012 ¹⁰⁷	Focus Groups and Interviews	To conduct a formative evaluation of an HIE for HIV that integrates public health and clinical information	Louisiana	Health department, hospital, outpatient	-Interview and focus groups -Logs of messages	February 1, 2009 and January 31, 2011	The Louisiana Public Health Information Exchange (LaPHIE)
Hessler, <i>et al.</i> , 2009 ⁷⁶	Online, cross-sectional survey	To understand assessment of HIE by RHIO and state and local public health department representatives	U.S.	RHIOs and State and Local Health Departments	Online survey created by researchers	late February 2007-March 25, 2007	Varies, NR

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Hamann and Bezboruah, 2013 ⁹⁸	Varies, NR	Varies	Long term care Facilities Nursing home is U.S. Residential Care (aka Assisted Living in U.S.)	Nursing home Sample: 1,174 response rate 81% Residential care Sample: 2,302 response rate 81% Various HIEs	NR	NR
Herwehe, <i>et al.</i> , 2012 ¹⁰⁷	A secure bi-directional public health informatics application (an HIE in a broad sense, as defined by Dixon <i>et al.</i>), linking statewide public health surveillance data with patient-level EMR data.	Started February 2009 and in all participating hospitals by September 2009	Patients with HIV seen for non HIV services at 7 Louisiana Hospitals; 442 clinicians (206 physicians and 236 nurses) trained on system to serve as peer trainers	16 focus groups n=149; and 23 key informant interviews with patients	NA	NA
Hessler, <i>et al.</i> , 2009 ⁷⁶	Varies, NR	Varies	164 RHIOs 540 health agencies	N=44 RHIOs (27% response); 20 non-governmental N=138 Health agencies (26% response); 41 state and 97 local public health agencies	RHIOs: listed in 1 of 7 sources Public Health: on list from national associations	Missing or invalid email addresses or an exchange specific to 1 disease

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Hamann and Bezboruah, 2013 ⁹⁸	Nonprofit vs. for profit use of health IT including HIE	Whether facility shares information electronically with other care partners and the extent of HIE defined as the number of entities with which the facility shares information	Non profit or for-profit ownership	<ul style="list-style-type: none"> -Chain ownership -Size of facility and type of residents -Use of volunteers -% revenue from Medicaid and Medicare 	<ul style="list-style-type: none"> -Chi² -Ordered Logit regression
Herwehe, <i>et al.</i> , 2012 ¹⁰⁷	NA	Patients identified and matched providers responses to alerts	NA	NA	<ul style="list-style-type: none"> Description Counts of alerts and responses
Hessler, <i>et al.</i> , 2009 ⁷⁶	RHIOs vs. state vs. local health officials	<ul style="list-style-type: none"> -Sharing of data -Challenges -Unique resources -Minimal requirements 	Type of respondent	Characteristic reported but not used in analysis	<ul style="list-style-type: none"> -Descriptive statistics, no significance tests -Qualitative assessment of open-ended responses

Author, year	Results
Hamann and Bezboruah, 2013 ⁹⁸	<p>For Profit/Nonprofit (corrected F)</p> <p>% Residential care using HIE: 0.14/0.21 (10.29), p=0.00 Number of partners in HIE: 0.32/0.42 (2.56), p=0.02</p> <p>Regression results: for profits less likely to participate in HIE OR 0.663, p<0.001</p> <p>Supports hypothesis and proposed framework for why nonprofits are more likely to use health IT</p> <p>NOTE: NH survey did not have HIE question</p>
Herwehe, <i>et al.</i> , 2012 ¹⁰⁷	<p>In the 2 year period 2/1/2009 to 1/31/2011:</p> <ul style="list-style-type: none"> -488 registrations of patient (345 unique patients) with HIV identified -Clinicians responded to 73% of alerts and documented actions on note that was shared with public health -Results include statement that 'no negative feedback has been received from providers' with no detail -Summary of patient interviews found general acceptance of data sharing as long as there was patient benefit and a preference for care in the healthcare verses the public health system -Challenges: concerns about data ownership and ethics and disparate data systems, but these are reported as challenges they were able to address
Hessler, <i>et al.</i> , 2009 ⁷⁶	<p>Public Health: 50 (36%) no RHIO in jurisdiction; 16 (12%) no relationship with RHIO; 26 (40% responding to item) are exchanging information</p> <p>RHIOs: 12 (60%) are exchanging info; 7 (35% with public health); lab data shared most frequently (86% of the time)</p> <p>Challenges (RHIO/Local/State % endorsing)</p> <p>Lack of standards: 33/12/15 Limited resources: 17/67/45</p> <p>Unique resources Public Health brings</p> <p>Perspective: 41/45/30 Data: 35/16/39</p> <p>Minimum Public Health must bring</p> <p>Commitment: 50/31/23 Funding/sweat equity: 33/43/47</p> <p>More dialogue about needs and expectations could increase HIE; early successes with lab data could encourage future use.</p>

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Hincapie, <i>et al.</i> , 2011 ¹⁰⁹	Focus group	Assess perceptions of physicians users of HIE	Arizona	All physician use	Focus group meetings of 29 physicians on HIE quality of care, workflow and cost	NR	Arizona Medical Information Exchange (AMIE)
Jha, <i>et al.</i> , 2008 ¹⁰²	Cross sectional, mixed modes	To assess health IT, including HIE adoption in 7 countries	U.S., U.K., Canada, Germany, Netherlands, Australia, New Zealand	Physicians and hospitals	Literature review, available surveys, (Medline and Google) and interviews with governmental and non governmental experts	Literature review: 2000 -2006	Varies, NR
Johnson, <i>et al.</i> , 2008 ⁸⁴	Analyze of HIE logs; user feedback	To assess first year of MidSouth eHealth Alliance	Memphis, Tennessee	EDs	User activity logs, patient demographics, clinical data message logs, comments by users	Implied 1 year after May 2006; but data on use in January 2008	MidSouth eHealth Alliance (MSeHA)

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Hincapie, <i>et al.</i> , 2011 ¹⁰⁹	Medication history, lab test results, and discharge summaries	October 2008	Physicians who agreed to participate in focus groups	29 physicians	Physicians who agreed to use system and participate in focus groups	None
Jha, <i>et al.</i> , 2008 ¹⁰²	Varies, NR	Varies	Developed countries	7 selected for data availability	NA	NA
Johnson, <i>et al.</i> , 2008 ⁸⁴	Multiple hospital emergency departments and community-based ambulatory clinics. Decentralized, query-based exchange. Data Exchanged: demographics, ICD-9 discharge codes, lab results, encounter data, and dictated reports. These are in a vault controlled by the hospital, but accessed when a query is made, unless patient opts out.	May 2006	ED staff in 5 participating sites	5 sites; number of users varies by site	NR	NR

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Hincapie, <i>et al.</i> , 2011 ¹⁰⁹	None	Benefits and disadvantages of HIE	Transcripts	NA	Themes extracted from transcripts
Jha, <i>et al.</i> , 2008 ¹⁰²	HIE use across countries	<ul style="list-style-type: none"> -HIE existence -Use -Policies promoting development 	Country	NR	Descriptive, qualitative
Johnson, <i>et al.</i> , 2008 ⁸⁴	HIE use across sites and overall	<ul style="list-style-type: none"> -% of ED visits with HIE use -% of users who logged in -Theme from comments: perception that HIE reduces redundant testing was most common 	NA	Role (Nurse, MD, registrar, unit clerk)	Counts and percentages

Author, year	Results
Hincapie, <i>et al.</i> , 2011 ¹⁰⁹	Benefits included identification of "doctor shopping", avoiding duplicate testing, and increased efficacy for gathering information; disadvantage was limited availability of data
Jha, <i>et al.</i> , 2008 ¹⁰²	<p>Australia: early pilots, but no major investment. Lack of unified patient identification an issue</p> <p>Canada: province-wide efforts, particularly Alberta; national--early development of Health Infoway but little info exchanged</p> <p>Germany: most computers with records not connected; Germans have smart cards, but only admin data now</p> <p>Netherlands: National SwithPoint pilot with 20% of population, plan full implementation in 2008</p> <p>New Zealand: planning stage, have unified patient Id, focus of discharge, lab and path reports to GPs</p> <p>U.K.: National Program, but mostly small amount of data exchanged in more minor programs</p> <p>U.S.: RHIOs, but <12% of organizations exchanging data and <1% of population involved</p>
Johnson, <i>et al.</i> , 2008 ⁸⁴	<p>HIE viewed in 2.6% of all visits and 9.5% of visits where patient had visit to other site in past 30 days.</p> <p>% of total users who logged on ranged from 0 in one site where the high was 12% to 75% by unit clerks in a site that had high use by other professions</p> <p>-MSeHA was used for 3% of all visits</p> <p>-The site with the highest usage had registrars looking up HIE data when patient arrived at the ED</p> <p>-The site that mostly serves pediatric patients used MSeHA the least vs. other sites</p>

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Johnson, <i>et al.</i> , 2011 ¹⁰³	Mixed methods	To explore characteristics of use and uses of a regional HIE	Memphis, Tennessee	EDs, ambulatory groups	Audit logs, comment cards, feedback in system, interviews, observations, ED claims	Interviews 1 month, 1 year after system in use in all sites Audit data and ED visits January 2008-June 2008	MidSouth eHealth Alliance (MSeHA)
Jones, Friedberg and Schneider, <i>et al.</i> , 2011 ⁶⁰	Retrospective cohort	To evaluate the association between hospitals' HIE and health IT use and 30-day risk adjusted readmission	U.S.	Hospitals	2007 AHA Survey 2009 September Hospital Compare	June 2005-June 2008 for Hospital Compare	Varied. As defined by hospital
Kaelber, <i>et al.</i> , 2013 ¹⁰⁵	Measurement of HIE usage and survey of physician users	What is use and perceived value of HIE?	Northeast Ohio	Public healthcare system	Usage logs, survey of users	November 2010-December 2011	HIE in Northeast Ohio

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Johnson, <i>et al.</i> , 2011 ¹⁰³	Data Exchanged: demographics, ICD-9 discharge codes, lab results, encounter data, and dictated reports. Multiple hospital emergency departments and community-based ambulatory clinics. Decentralized. These are in a vault controlled by the hospital, but accessed when a query is made, unless patient opts out.	May 2006 in EDs later in clinics (NR)	6 ED sites and 9 clinics for interviews All visits records and usage logs	Number of people interviewed NR 369 comments (12% of all visits)	NA	NA
Jones, Friedberg and Schneider, <i>et al.</i> , 2011 ⁶⁰	Varied. As defined by hospital	Varied. As defined by hospital	Hospitals in U.S.	2,406 hospitals (58% of eligible hospitals responded to AHA survey)	General acute care non federally owned U.S. hospitals	Not specified. Specialty and federal implied by inclusion criteria
Kaelber, <i>et al.</i> , 2013 ¹⁰⁵	10 hospitals and affiliated practices using Care Everywhere	November 2010	Not stated for patient population, 412 physician users	74 (18%) of physicians who replied to survey	All users	NA

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Johnson, <i>et al.</i> , 2011 ¹⁰³	NA	-HIE Access -Type of data accessed -Provider log on rates	NA	-Profession (Doctors or nurse/clerk) -Type of visit	Counts and percentages
Jones, Friedberg and Schneider, <i>et al.</i> , 2011 ⁶⁰	Hospitals that self report exchanging any information with ambulatory providers outside their system vs., hospitals who say they do not participate in this type of HIE	All- cause 30-day risk-standardized readmission rates for patients initially admitted with acute myocardial infarction, heart failure, or pneumonia.	HIE Participation (also use of health IT)	Hospital characteristics (ownership, critical access status, trauma status, number of beds, teaching status, system membership, core-based statistical area type, U.S. census division, long term care unit, critical care unit)	-Unadjusted mean differences -Propensity score matching -Linear regression
Kaelber, <i>et al.</i> , 2013 ¹⁰⁵	-Measurement of usage -Perceptions of users	-Measurement of usage -Perceptions of users	-Usage of HIE -Survey of users	None	Log analysis and survey

Author, year	Results
Johnson, <i>et al.</i> , 2011 ¹⁰³	<p>HIE access</p> <p>Patient encounters increased over 24 months: 4% to 6.5% (range: 1 to 16 % across sites) 14.6% for return ED visits and 18.7% for return clinic visits (p<0.001) Higher where nurses and clerks involved and lowest where MD only access Patient opt out rates: 1% to 3% Primary user reported consequence of HIE: provided additional history (29%), prevented repeat test or procedure (19.8%)</p>
Jones, Friedberg and Schneider, <i>et al.</i> , 2011 ⁶⁰	<p>Unadjusted readmission rates (no HIE vs. HIE)</p> <p>Acute myocardial infarction: 20.0 vs. 19.8, p=0.14 Heart failure: 24.6 vs. 24.3, p=0.003 Pneumonia: 18.2 vs. 18.1, p=0.68</p> <p>Hospitals did not participate in HIE: 58.7%</p> <p>Adjusted readmission rates (no HIE vs. HIE)</p> <p>Acute myocardial infarction: 19.9 vs. 19.8, p=0.18 Heart failure: 24.4 vs. 24.2, p=0.11 Pneumonia: 18.2 vs. 18.1, p=0.68</p>
Kaelber, <i>et al.</i> , 2013 ¹⁰⁵	<p>Usage of HIE</p> <p>ED: 31% to 35% Primary care: 18% to 22% Specialty care: 9% to 11%</p> <p>-Usage highest among patients who were older, with more comorbid illness, Medicare/Medicaid insured, and black -Self-reported impact was more efficient care (93%), time savings (85%), prevented admissions (15%), decreased tests ordered (84%), decreased imaging ordered (74%), and improved care in other ways (82%)</p>

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Kaushal, <i>et al.</i> , 2010 ⁵²	Semi structured interviews Qualitative	To assess users experiences with an HIE project that provided medications information to EDs.	Massachusetts	5 Massachusetts Emergency Rooms	Interview covering need for intervention, history, personal use, induction, current us, completeness and accuracy, value added, rollout to other hospitals and evaluation Pharmacy benefit claims data	December 2005	MedsInfo-ED, a project Massachusetts Health Data Consortium (MHDC)
Kern, <i>et al.</i> , 2011 ¹⁴⁴ Same as Kern, <i>et al.</i> , 2009 ¹⁴⁰	Longitudinal cohort	To determine predictors of sustainability among community-based organizations implementing health IT including HIE in a state with significant funding of such organizations.	New York	Varies (setting was part of analysis)	Baseline assessment and New York State Department of Health information on awarded grants	Phone Interviews January-February 2007 (same as baseline for Kern, 2009). New York State Department of Health data: March 2008	Varies
Kern, <i>et al.</i> , 2009 ¹⁴⁰	Longitudinal, organizational assessment	To identify lessons for state-based initiatives that can be learned from HEAL NY	New York	NR	Baseline and followup assessments	Baseline: January-February 2007 Followup: July-August 2008	Varies

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Kaushal, <i>et al.</i> , 2010 ⁵²	Claims data from pharmacy benefit managers (PBMs) were made available at the point of care to clinicians in the Ends	2004	Staff at participating sites	N=12 interviewed of 15 contacted	3 EDs that were pilot sites; 2 more added in expansion. Agreement to participate from MassHealth and 5 health plans.	Patients not covered by participating plans
Kern, <i>et al.</i> , 2011 ¹⁴⁴ Same as Kern, <i>et al.</i> , 2009 ¹⁴⁰	NR	Varies	HEAL 1 Grantees given awarded funds for health IT	26 Phase I grantees (100%)	HEAL 1 Grantee	NA
Kern, <i>et al.</i> , 2009 ¹⁴⁰	NR	Varies	HEAL Grantees given awarded funds for health IT	26 HEAL grantees	NA	NA

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Kaushal, <i>et al.</i> , 2010 ⁵²	Comparisons across the 3 initial pilot sites	Descriptive narrative only	NA	NA	Coding of interview transcripts by two investigators
Kern, <i>et al.</i> , 2011 ¹⁴⁴ Same as Kern, <i>et al.</i> , 2009 ¹⁴⁰	Organizations that received further funding vs. those that did not	Receipt of HEAL 5 funds	-Responses to 26 questions covering 9 areas -Type of organization that was the lead application (health care or health information)	NA	-Bivariate and multivariate logistic regression -Backward stepwise elimination
Kern, <i>et al.</i> , 2009 ¹⁴⁰	NA	-Grantee still in operation -Exchanging data or implementing other IT -Met definition of RHIO	NA	None reported	-Counts and proportions -McNemar 2-sample test for binomial proportions for matched-pair data for comparison between baseline and followup

Author, year	Results
Kaushal, <i>et al.</i> , 2010 ⁵²	<p>Need: respondents believed gaps in medical information are an important problem and this system could help Information was perceived as accurate, range of estimate of patients with information 15% to 80%</p> <p>Perception: system improved knowledge but did not decrease time and did not improve care enough to justify hospital paying for system</p> <p>Barriers: need for patient consent, difficulty matching patients</p> <p>Suggestions: increasing the types of information included (e.g., psychiatric, HIV, and mail order medications) and improving the format of the output</p>
Kern, <i>et al.</i> , 2011 ¹⁴⁴ Same as Kern, <i>et al.</i> , 2009 ¹⁴⁰	<p>Predictors of funding from bivariate (OR, 95%CI) Lead by health information organization: 11.4, 1.7 to 78.4, p=0.01 Performed community-based needs assessment: 5.1, 0.8 to 32.3, p=0.08 Targeting long term care settings: 0.14, 0.02 to 0.79, p=0.03</p> <p>Predictors of funding from multivariate (OR, 95%CI) Lead by health information organization: 6.4, 0.8 to 52.6, p=-.08</p>
Kern, <i>et al.</i> , 2009 ¹⁴⁰	<ul style="list-style-type: none"> -All grantees still existed at followup -Half decreased number of planned projects (3 possible: HIE EHR, electronic prescriptions) -HIE all grantees planning at baseline, 85% at followup (22 of 26) -9 (35%) had users ranging from 5 to 1600. HIE was most common project. -13 baseline/20 followup met definition of RHIO -Expected interventions (not just HIE) to save money: 65% baseline, 35% followup p=0.02 -Concern about financial and technical barriers increased by followup

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Kern, <i>et al.</i> , 2012 ³⁷	Retrospective cohort	To determine the effect of HIE on ambulatory quality	Hudson Valley region, New York	Physician small group practices	From Portal for usage, MVP Health Care Quality Reports including HEDIS measures and satisfaction	January 2005-June 2006 (split into 3 6-month periods)	MedAllies Portal covers 2 counties, 5 hospitals, and 2 labs
Kern, <i>et al.</i> , 2012 ¹⁴³	Secondary analysis of reports in the literature	To understand which components of EHRs and HIE are most likely to drive financial savings in the ambulatory, inpatient, and ED settings.	NA	Ambulatory, inpatient, and ED settings.	Literature search results, input of 28 national experts, analysis of Stage 1 of Meaningful Use	April 2007 (expert review)	NA
Kho, <i>et al.</i> , 2013 ⁷⁷	Descriptive and user survey	To describe the use of an HIE for tracking patients with antimicrobial resistance	Indianapolis, Indiana	Hospital and associated clinics	System use, survey of key users (infection preventionists)	June 2007-June 2010	Indiana Network for Patient Care (INPC)

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Kern, <i>et al.</i> , 2012 ³⁷	Internet-based with secure log-in from any computer. Providers can view tests and results order by themselves or others.	2001	Taconic Independent Practice Association MDs	138 MDs with quality information (out of 168, 82%) 79 nonusers and 59 users of the HIE portal	≥150 patients with MVP Health Care	No quality of care data
Kern, <i>et al.</i> , 2012 ¹⁴³	NA	NA	HIE functions by settings	Top 10 functions based on researcher ratings	In top 10 for function based on: 1) probability of achieving a benefit, 2) time to benefit, 3) probability of measuring a benefit for initial framework. Experts added 3 additional criteria 4) complexity, 5) likelihood of usage, and 6) expected magnitude of impact	Rating below top 10
Kho, <i>et al.</i> , 2013 ⁷⁷	5 hospital systems (17 hospitals)	May 2007 for this tracking function	Infection preventionists at all hospitals; patients with MRSA or VRE	NR	NA	NA

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Kern, <i>et al.</i> , 2012 ³⁷	Physicians who used portal vs. those who did not	<ul style="list-style-type: none"> -Rate of portal use -Quality of care 	Any portal use	<ul style="list-style-type: none"> -Physician characteristics -Case mix 	<ul style="list-style-type: none"> -Chi² -t-tests -Fischer exact tests -Generalized estimating equation regression
Kern, <i>et al.</i> , 2012 ¹⁴³	High rated functions across setting and between HIE and EHRs	Rating of function	Setting type (HIE, EHRs)	NA	ANOVA for scores across settings t-tests for HIE, EHRs comparisons
Kho, <i>et al.</i> , 2013 ⁷⁷	NA	<ul style="list-style-type: none"> -Number of alerts generated -Number of patients admitted to multiple hospitals -User satisfaction/ burden -Coordinated antibiotic-resistant infection tracking, alerting and prevention 	NA	NA	Counts

Author, year	Results
Kern, <i>et al.</i> , 2012 ³⁷	<ul style="list-style-type: none"> -% of MDs using portal: 33% months 1-6 vs. 42% months 7-12 vs. 43% months 13-18 -Mean days logged in per month by MD: 8 (SD 6) -Quality score at followup: 49 for non users vs. 64 for users, p<0.0001 -OR for higher quality use of portal: 1.42 (95% CI, 1.04 to 1.95) -Average ambulatory quality of care for composite of 15 measures, stratified by time and use of HIE showed difference between non-users vs. users (49% vs. 64%, p<0.0001) at followup and among users between baseline vs. follow-up (57% vs. 64%, p<0.001)
Kern, <i>et al.</i> , 2012 ¹⁴³	<ul style="list-style-type: none"> -73 setting-HIE function pairs were identified -Mean function score (range 6 to 18): 13.0 EHR vs. 11.3 HIE, p<0.0001 -No difference in scores across setting (p=0.33) -High scoring HIE functions: transferring imaging reports (all settings), receiving lab results (outpatient and ED), enabling structured medication reconciliation -HIE functions were considered more difficult to implement (complexity and time) vs. EHRs -HIE is most likely to generate a positive financial effect through its ability to coordinate care among providers. Based on assessment for EHRs adding decision support to HIE could potentially yield even greater financial returns
Kho, <i>et al.</i> , 2013 ⁷⁷	<p>Over 3 years</p> <ul style="list-style-type: none"> -12,748 email alerts on 6,270 unique patients -23% (MSRA) and 22% (VRE) had previous history identified at a different hospital system <p>10 Infection Preventionists surveyed</p> <ul style="list-style-type: none"> -All reported email alerts were useful -Estimated receiving 5 alerts per day; half already known; alerts used to identify patients requiring intervention -3 said system added time, 1 saved time, 6 neutral -Most comment recommendation was to add automate capture of lab data

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Kierkegaard, Kaushal and Vest, 2014 ¹¹⁰	Multi site case study	To investigate how HIE can better meet the needs of care practitioners	3 communities (RHIOs) in New York State	ED and outpatients	2 day site visits, onsite and telephone interviews with HIE users and non users, observations of workflow	May-June 2013	NA
Lammers, Adler-Milstein and Kocher, 2014 ⁶¹	Retrospective cohort	To evaluate whether HIE is associated with decreases in repeat imaging in EDs	California and Florida	EDs	State ED databases, Health Information Management Systems Society data, AHA annual survey	2007-2010	Varies, not a single HIE
Lang, <i>et al.</i> , 2006 ⁵⁷	Crossover cluster RCT	Impact of sending family physicians electronic vs. mailed reports of ED visits for their patients	Montreal, Canada	ED and family physician practices	Surveys and determination of patient outcomes	June 2001-April 2002	Adult university teaching hospital in Montreal

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Kierkegaard, Kaushal and Vest, 2014 ¹¹⁰	2 federated model, 1 centralized model. All required login to standalone web portal 2 provided automated delivery of imaging and lab results 1 included patient portal and iPhone app 1 included secure messaging and event notification. Query-based but also provided direct exchange of CCD	NR	11 RHIOs in NY and users and non users of HIE	N= 38 interviews 3 sites (13, 15, 10) 3 EDs, 7 outpatient 3 types of respondents: MDs, other clinical users, administrative users	Received HEAL NY funding and been in existence for ≥7 years, and distinct.	NA
Lammers, Adler-Milstein and Kocher, 2014 ⁶¹	Varies	Varies	ED visits in California and Florida	Patients at HIE adopters: 33,084 (11%) Patients at non adopters: 274,640	ED visits with data in State and HIMSS, patient had another ED visit in prior 30 days in different EDs, or selected imaging in index visit	ED visits that resulted in admissions
Lang, <i>et al.</i> , 2006 ⁵⁷	Report of ED visit sent to family physicians	NR	Patients visiting ED during 0800-2200	2,022 (out of 3,168) patients visiting ED	Patients visiting ED	Patients in altered mental state (129), state of agitation (21), or with language barrier (29)

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Kierkegaard, Kaushal and Vest, 2014 ¹¹⁰	Themes across sites	Themes related to use of HIE	Site and type of setting	NA	<ul style="list-style-type: none"> -Dual coding of interviews -Iterative coding, grouping of themes in categories continued until saturation
Lammers, Adler-Milstein and Kocher, 2014 ⁶¹	37 EDs that participated in HIE vs. 410 that did not	Repeat CT, ultrasound or chest x-ray in same body region within 30 days at unaffiliated EDs	HIE participation in each year	<ul style="list-style-type: none"> -Patient demographics -Number of days between ED visits -comorbidities -Total annual ED discharges -ED characteristics 	Regression with fixed effects and trends
Lang, <i>et al.</i> , 2006 ⁵⁷	ED visit summary provided electronically vs. on paper sent by mail	<ul style="list-style-type: none"> -Physician satisfaction -Return visits at 14 and 28 days -Duplication of requests for diagnostic tests -Duplication of specialty consult requests - Economic 	<ul style="list-style-type: none"> -Physician satisfaction -Return visits at 14 and 28 days -Duplication of requests for diagnostic tests -Duplication of specialty consult requests 	Physicians already are sent carbon copies of first page of ED note; self-report of followup data	Survey, analysis of followup care

Author, year	Results
Kierkegaard, Kaushal and Vest, 2014 ¹¹⁰	<p>Availability of information varied based on patient consent (required in New York State) and healthcare organization participation.</p> <p>USE</p> <ul style="list-style-type: none"> -MDs had low tolerance for search failures. -Practice staff are important to obtaining patient consent. Where clerks were not trained or supported, fewer patients consented. -Patients saw providers covered by other exchanges, suggesting need for larger areas -Physician use HIE less than other clinical users; MDs often delegate the task. <p>USABILITY</p> <ul style="list-style-type: none"> -Login process perceived as a burden -Slow system response times
Lammers, Adler-Milstein and Kocher, 2014 ⁶¹	<p>Probability of repeat ED imaging (percentage points [95% CI]), relative reduction</p> <p>CT: -8.7 (-14.7 to -2.7), 59%</p> <p>Ultrasound: -9.1 (-17.2 to -1.1), 44%</p> <p>Chest x-ray: -13.0 (-18.3 to -7.7), 67%</p> <ul style="list-style-type: none"> -Repeat tests more likely in large EDs
Lang, <i>et al.</i> , 2006 ⁵⁷	<ul style="list-style-type: none"> -Reports found to be received, especially in timely manner, and were more likely to be legible, comprehensive, and useful. -No difference in return visits within 14 and 28 days, although near significance for fewer visits for patients >65 years within 28 days. -No difference in duplicate test ordering but greater subspecialty consult requests in intervention group.

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Lee, <i>et al.</i> , 2012 ⁷⁸	Pre-post implementation survey	To understand MD perception prior to HIE implementation and post implementation use and evaluation	South Korea	Hospital and ambulatory clinics	Survey responses, records of data transfer	June 2008 Week 1 and 2 (pre survey) Post: NR	Seoul National University Bundag Hospital and 35 clinics

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Lee, <i>et al.</i> , 2012 ⁷⁸	Federated architecture model with ebXML RS and ebSML RIM standards Included demographics, diagnoses, medications, lab results, imaging, treatment, care plans, vital signs, history and summaries.	June 2008 with updates October 2009	MDs in hospital (50) and clinics (147) for pre; MDs using the HIE for post	23 from hospital and 48 from 20 clinics (46% and 33% response) for pre; 15 from hospital and 25 from clinics for post out of all MDs using the system	MD at pilot site	<50% of items completed

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Lee, <i>et al.</i> , 2012 ⁷⁸	Hospital vs. clinic based MDs	<ul style="list-style-type: none"> -Pre: Perceptions -Post: Information transmission rate Information utilization rate 	Setting (hospital vs. clinic based)	<ul style="list-style-type: none"> -Gender -Age -Specialty 	Fischer exact tests

Author, year	Results
Lee, <i>et al.</i> , 2012 ⁷⁸	<p>Pre HIE</p> <p>-Mean Likert scale that HIE is needed (5 strongly agree): 4.2, $p=0.8888$ for all and by setting. Similar responses about the need for HIE for specific items (e.g., lab reports) and perceived benefits of HIE.</p> <p>-Hospital based MDs had higher levels of agreement about concerns related to HIE than clinic based MDs</p> <p>Post HIE</p> <p><i>Most commonly transmitted information differed by setting</i></p> <p>From hospital was working diagnosis: 99.5% vs . 70.5% for clinic, $p<0.0001$</p> <p>From clinic it was clinical findings: 79.8%, but this did not differ from hospital</p> <p>The most useful was lab or imaging in both settings but it was more frequently rated as useful by hospitals (88.2% and 72.9% of cases $p<0.0001$)</p>

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Lobach, <i>et al.</i> , 2007 ⁸⁵	Descriptive	To describe use of an HIE for population health management	Durham County, North Carolina	Outpatient	System logs	September 2006-February 2007	Northern Piedmont Community Care Network set up a system called COACH (Community-Oriented Approach to Coordinated Healthcare) includes 32 private practices, 3 federally qualified health centers, 4 community hospitals, 9 government agencies (county health departments and departments of social services), 1 academic medical center, and 2 care management teams: Durham County, North Carolina, Medicaid
Maass, <i>et al.</i> , 2008 ⁵³	Time-motion study of care of 20 diabetic patients that was facilitated by HIE	Ascertain benefits of HIE when they occurred	Finland	Regional information system for exchange of clinical data between hospital and primary care offices	Time-motion study of diabetic patients in a health center	NR	Regional information system in Finland

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Lobach, <i>et al.</i> , 2007 ⁸⁵	The 4 types of data collected by the system include*: 1) administrative (demographics and identifiers, services used, provider associations, audit trails); 2) care management (care management encounters, health risk and environment assessment, socio-economic data, special needs, and care management plans); 3) clinical (encounters, problems/procedures, missed appointments, medications, allergies, laboratory results, disease-specific care plans); and 4) communication (messages and alerts, referrals, notices of new information).	2001	Patients in program	11,899 patients in Durham County in Medicaid	NA	NA
Maass, <i>et al.</i> , 2008 ⁵³	Transmission of patient data into physician EHR	NR	Physicians in health centers in Finland	20 visits by patients with diabetes	NR	NR

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Lobach, <i>et al.</i> , 2007 ⁸⁵	NA	Sentinel events: resource utilization by patients (events of commission) that were considered excessive (e.g., 3 ED visits in 90 days) or potentially avoidable (e.g., ED visit for asthma) and that could potentially be modified by the involvement of care managers and other providers	None	None	Counts, observation
Maass, <i>et al.</i> , 2008 ⁵³	Use of information system and description of benefits	Use of information system and description of benefits	System used and benefits described	NA	Time-motion study

Author, year	Results
Lobach, <i>et al.</i> , 2007 ⁸⁵	<p>In an analysis of 11,899 continuously enrolled patients from a single county over a six-month period 19.3% (2,285 unique patients) had 7,226 sentinel health events</p> <p>Frequency of types of events</p> <p>Hospital admit asthma: 43 Hospital admit diabetes: 76 Low-severity ED: 2, 546 ≥2 missed appointments in 60 days: 1,728</p> <p>Implementation lessons</p> <ul style="list-style-type: none"> -Political issues are more challenging than technical issues -Perceived value of notices was dependent on timeliness and completeness of underlying HIE dataset. -Difficult to determine who should be notified of these events, how many notices should be resent and how to prioritize them.
Maass, <i>et al.</i> , 2008 ⁵³	20 visits, 4 involved use of information system, with 1 allowing faster treatment decision and 3 providing access to latest test results

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Machan, Ammenwerth and Schabetsberger, 2006 ⁵⁴	Qualitative development of instrument followed by quantitative usage Cross-sectional Survey	Assess value of different aspects of regional network of hospitals and physician practices	Tyrol region of Austria	Regional information system for exchange of clinical data between hospital and primary care offices	Initial qualitative development of survey followed by quantitative evaluation of responses	May-August 2004	Tiroler Landeskrankenanstalten (TILAK)
Mäenpää, <i>et al.</i> , 2011 ³⁸	Retrospective study of HIE use and impact on test ordering and referrals	What is impact of a regional health information system on test ordering and referrals?	Tampere, Finland	Hospital district that includes 1 hospital district and its community health system. Outpatient	Usage of HIE and ordering of laboratory and radiology tests as well as specialty referrals	Data collected 2004-2008	Regional information system in Finland
Mäenpää, <i>et al.</i> , 2012 ¹⁰⁰	Retrospective study of HIE use and impact on test ordering and referrals	What is usage of a regional health information system for different amounts of test ordering and referrals?	Tampere, Finland	Hospital district that includes 1 hospital district and its community health system	Usage of HIE and ordering of laboratory and radiology tests as well as specialty referrals	Data collected 2004-2008	Regional information system in Finland

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Machan, Ammenwerth and Schabetsberger, 2006 ⁵⁴	Transmission of discharge letters and clinical findings from hospitals to general practitioners. Direct exchange via email	June 2003	General practitioners in Tyrol, Austria	4 providers followed by cross-sectional survey of 104 of 242 (43%) providers.	All general practitioners in Tyrol	None
Mäenpää, <i>et al.</i> , 2011 ³⁸	Full medical record in regional information system	2004	About 234,000 inhabitants in hospital district and associated clinics	NR	NA	NA
Mäenpää, <i>et al.</i> , 2012 ¹⁰⁰	Full medical record in regional information system	2004	10 municipalities; About 234,000 inhabitants in hospital district and associated clinics	NR	NA	NA

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Machan, Ammenwerth and Schabetsberger, 2006 ⁵⁴	None	-Measurement of overall satisfaction -Desirability for receiving reports electronically -Reduced work for filing and archiving -Leading to improved quality of care	Survey	NA	Survey
Mäenpää, <i>et al.</i> , 2011 ³⁸	Appointments, ED visits, laboratory and radiology tests for primary and specialty care	-Rates of laboratory and radiology test ordering -ED visits and primary care referrals	None	Use of HIE not correlated specifically with outcomes	Log analysis
Mäenpää, <i>et al.</i> , 2012 ¹⁰⁰	Usage of HIE by physicians, nurses, and department secretaries, and number of appointments, ED visits, and laboratory and radiology tests	-Rates of laboratory and radiology test ordering -ED visits and primary care referrals	Usage of HIE	Use of HIE not correlated specifically with outcomes	Log analysis

Author, year	Results
Machan, Ammenwerth and Schabetsberger, 2006 ⁵⁴	<p>Satisfaction with HIE</p> <p>Positive: 66.4%</p> <p>Agreeing desirable for receiving all reports electronically: 83.7%</p> <p>Reporting less work for filing and archiving: 82.7%</p> <p>Agreeing it led to improved quality of care: 78.8%</p>
Mäenpää, <i>et al.</i> , 2011 ³⁸	<p>Change in rates of ordering over time (primary vs. specialty care)</p> <p>Laboratory tests per appointment: 19.0% vs. 7.0%</p> <p>Laboratory tests per inhabitant: 19.0%, 17.9%</p> <p>Clinical chemistry ordering per appointment: 6.6% overall</p> <p>Clinical chemistry ordering per inhabitant: 17.5% overall</p> <p>Radiology exams per appointment: -16.4% vs. -11.0%</p> <p>Radiology exams per inhabitant: -18.9% vs. -1.9%</p> <p>ED visits: -1%, -16.2%</p> <p>Primary care referral to specialist per appointment: 43.6%</p> <p>Primary care referral to specialist per inhabitant: 35.2%</p>
Mäenpää, <i>et al.</i> , 2012 ¹⁰⁰	<p>Usage of HIE (views per year)</p> <p>Physicians: 1,333</p> <p>Nurses: 758</p> <p>Department secretaries: 497</p> <p>-No associations detected between use of HIE and test ordering outcomes</p> <p>References (means one view of the HIE) viewed in primary health care in 2004–2008:</p> <p>By physicians from n=486 to n=3581</p> <p>By nurses from n=59 to n=2,3535</p> <p>By department secretaries from n=26 to n=13,542</p> <p>References viewed in special care in 2004–2008:</p> <p>By physicians from n=1,496 to n=25,051</p> <p>By nurses from n=284 to n=20,587</p> <p>By department secretaries from n=1,156 to n=6,958</p> <p>-The HIE utilization rates increased annually in all 10 federations of municipalities, and the viewing of reference information increased steadily in each professional group over the 5-year study period. In these federations, a significant connection was found to the number of laboratory tests and radiology examinations, with a statistically significant increase in the number of viewed references and use of HIE. The higher the numbers of emergency visits and appointments, the higher the numbers of emergency referrals to specialized care, viewed references, and HIE usage among the groups of different health care professionals.</p>

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Magnus, <i>et al.</i> , 2012 ³⁹ ; Herwehe, <i>et al.</i> , 2012 ¹⁰⁷	Prospective case-cohort	To describe patients identified by the LaPHIE system and HIV-related outcomes associated with LaPHIE over 2 years.	Louisiana	HIV specialty, inpatient and outpatient care within Louisiana State University Health Care Division system. Includes 7 safety net hospitals	Alerts for HIV patients that continue to appear until patients receive CD4 or VL testing; actions taken by the provider are documented within the structured EMR	February 1, 2009-July 31, 2011	Seven safety-net hospitals;
Massy-Westropp, <i>et al.</i> , 2005 ¹¹¹	Mixed: cross-sectional survey and focus group sessions	Pilot the effectiveness of electronic data linking tools to assist in the transfer of information between an acute care hospital and the main regional provider of home-based care.	Adelaide, South Australia	Link patient health information between the hospital and community services sector	Email alert to community; remote access to hospital reports; flag community patients; web access to community reports.	Piloted over 6 months 2002-2003	Public teaching hospital, ED and aged home-based care community services organization.
McCarthy, <i>et al.</i> , 2014 ¹²²	Comparative case study of 7 HIEs funded by Beacon Community grants	Factors influencing technical architecture, clinical outcomes, and challenges for Beacon funded HIEs	Regions within Maine, Indiana, Ohio, Washington, Pennsylvania, Oklahoma, New York	Any	Written and telephone interviews of implementers of 7 HIEs	NR	Beacon Communities within Maine, Indiana, Ohio, Washington, Pennsylvania, Oklahoma, New York

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Magnus, <i>et al.</i> , 2012 ³⁹ ; Herwehe, <i>et al.</i> , 2012 ¹⁰⁷	LaPHIE is a secure bi-directional public health informatics application linking statewide public health surveillance data with patient-level EMR data. The exchange functions in real-time throughout the integrated data networks emergency departments, primary care and specialty ambulatory clinics, and inpatient units.	February-September 2009 (Herewehe, 2012)	HIV patients coming to Louisiana State University Health Care Services division clinics or ED.	419 patients in 60 clinics; alerts to 223 clinicians	HIV persons identified by LaPHIE with no CD4 or VL monitoring in >1 year, were followed in 6-month intervals for retention in HIV specialty care, inpatient and outpatient healthcare utilization	HIV patients who had been seen within past year and had no break in care of >1 year since diagnosis
Massy-Westropp, <i>et al.</i> , 2005 ¹¹¹	Email alert to community; remote access to hospital reports; flag community patients; web access to community reports.	Piloted over 6 months 2002-2003	Medical, nursing, and allied-health staff across the organizations	82 medical, nursing and allied-health staff. HIE included up to 4,000 patients. Satisfaction survey responses from 55 or 132 nurses, clinicians and allied health staff.	NR	NR
McCarthy, <i>et al.</i> , 2014 ¹²²	Varied from hybrid-federated to centralized	1994-2009, depending on HIE	Operational, technical, and clinical leaders of each HIE	NR	NA	None

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Magnus, <i>et al.</i> , 2012 ³⁹ ; Herwehe, <i>et al.</i> , 2012 ¹⁰⁷	Time-matched random sample of HIV-infected persons who had been seen for HIV care within the Louisiana State University Health Care Services Division integrated data network ≥ 1 within the past 5 years at the time of comparison.	<ul style="list-style-type: none"> -CD4 <200 cells/mm³ -VL >10,000 RNA copies/mL -Having been prescribed antiretroviral treatment during each 6-month interval 	Use of LaPHIE	Adjusted for demographic and clinical characteristics and timing of entry into the cohort	<ul style="list-style-type: none"> -Chi² tests, unadjusted logistic regression, and adjusted logistic regression -Generalized estimating equations using an exchangeable correlation matrix
Massy-Westropp, <i>et al.</i> , 2005 ¹¹¹	82 respondents of HIE project vs. 50 care providers outside of the HIE project	Satisfaction with electronic data linking	NA	NA	Descriptive
McCarthy, <i>et al.</i> , 2014 ¹²²	Compared various factors across hybrid-federated vs. centralized HIEs	<ul style="list-style-type: none"> -Trust -EHR context -Clinical transformation -Clinical research 	Qualitative	NA	Interviews

Author, year	Results
Magnus, <i>et al.</i> , 2012 ³⁹ ; Herwehe, <i>et al.</i> , 2012 ¹⁰⁷	<p>"After adjustment for demographic and clinical characteristics and timing of entry into the cohort, the LaPHIE-identified group remained significantly more likely to be immunocompromised (CD4 < 200 cells/mm³) than their counterparts (OR 3.22, 95% CI 1.72 to 6.04, p<0.001). However, there was improvement over time, with a decrease in odds of having a CD4 < 200 cells/mm³ at each successive six-month interval (OR 0.91, 95% CI 0.83 to 0.99, p<0.05). VL proved more responsive to changes in treatment and care; LaPHIE-identified persons rapidly became similar to their in-care counterparts, with no significant differences between VL, and again, decreased odds of having a VL > 10,000 copies/mL at each successive interval (OR 0.83, 95% CI 0.73 to 0.93, p<0.01)."</p> <p>24% of those identified had not had a CD4 count or VL since initial diagnosis. Of remaining 76% who had been in care previously, 55% had been out of care for ≥18 months. Following LaPHIE identification, 42% had CD4 counts < 200 cells/mm³ and 62% had VL >10,000 RNA copies/mL. Of 344 patients with at least 6 months of followup, 85% had ≥1 CD4 and/or VL after being identified.</p>
Massy-Westropp, <i>et al.</i> , 2005 ¹¹¹	<p>Provided bar graphs (figures 2 and 3) but not specific quantitative results except for a statement about use and satisfaction. Those who had embraced the use of the Integration tools were significantly more likely to rate integration higher than those who were not using it as often (p<0.001). In the discussion they estimated a 20% savings in staff time.</p>
McCarthy, <i>et al.</i> , 2014 ¹²²	<p>Hybrid-federated models maintain autonomy, accommodate disparate EHRs, and build incrementally, while centralized models require trust fabric, leverage common EHRs, and while providing long-run cost-efficiency may require larger upfront investment. Hybrid-federated models provide most functionality at individual organization level while centralized models leverage value of communitywide data and usage.</p>

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
McCullough, <i>et al.</i> , 2014 ¹¹²	Key informant interviews	To assess barriers and benefits to HIE participation in 2 underserved settings	San Gabriel Valley, California and Minneapolis St. Paul, Minnesota	Outpatient small practices (California) and federally qualified health centers (Minnesota)	Interview responses	NR	Citrus Valley Health Partners Federally Qualified Health Center Urban Health Network (FUHN)
McGowan, <i>et al.</i> , 2007 ¹³²	Interviews and document review	To ascertain lessons learned in the development of Vermont's RHIO	Vermont	NR	Interviews and documents and presentations about the development of VTMEDNET	NR	VTMEDNET (early HIE) and more recent statewide RHIO

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
McCullough, <i>et al.</i> , 2014 ¹¹²	<p>California: Collaborate system. a web-based tool enabling all providers to view data exchanged from 3 hospitals, an anticipated 90 providers, and laboratories in the community and to securely message other providers. Data are available to be viewed by all participating providers, regardless of whether a physician is contributing data to the system.</p> <p>Minnesota: CentraHealth aimed at enabling electronic exchange between FQHCs and the hospitals serving their Accountable Care Organization patients. This system was in implementation at time of study</p>	NR	Independent practices serving predominately Hispanic patients and federally qualified health centers developing an accountable care organization	N=24 providers, administrators, and office staff in 16 sites	Individuals who would be involved in adoption decisions and integration of HIE into workflows at each organization	None
McGowan, <i>et al.</i> , 2007 ¹³²	Federally funded (NLM and AHRQ) initiated by hospitals, but developed by a coalition. No other detail provided	NR	NA	5 interviews: 2 CIO of hospitals and 3 key leaders	NA	NA

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
McCullough, <i>et al.</i> , 2014 ¹¹²	None	Benefits and barriers to HIE use	NA	NA	Qualitative assessment of themes from interviews
McGowan, <i>et al.</i> , 2007 ¹³²	Description of 2 efforts. Some limited comparison of the 2	Facilitators and barriers to creation and implementation	NA	NA	Simple summary of interviews

Author, year	Results
McCullough, <i>et al.</i> , 2014 ¹¹²	<p>Barriers</p> <ul style="list-style-type: none"> -Lack of well-functioning area-level exchange -Market characteristics -Relationships or previous experiences with exchange partners -Challenge achieving a critical mass of users -Health IT used -Data ownership and provider liability concerns <p>Benefits</p> <ul style="list-style-type: none"> -Improved productivity at initial visit -Improved completeness of records -Avoidance of duplicative services/patient financial risk -Improved nonvisit consults
McGowan, <i>et al.</i> , 2007 ¹³²	<p>Major facilitators for success</p> <ul style="list-style-type: none"> -Public awareness -Provider buy-in -Benefits understood in terms of patient safety and quality of care <p>Barriers</p> <ul style="list-style-type: none"> -Perceived public perception of privacy issues -Providers lack working knowledge of HIE concepts -Need for a sustainable business model is recognized but not solved -Need for health information to cross state lines

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Merrill, <i>et al.</i> , 2013 ¹³⁷	Qualitative	Evaluate the complex dynamics involved in implementing electronic HIE for public health reporting at a state health department, and to identify policy implications to inform similar implementations	New York	State health department, 3 RHIOs	Lab results and other information for rapid and efficient identification, monitoring, investigation, and treatment of communicable and emerging diseases	2010-2011	3 RHIOs and New York State Department of Health.
Messer, <i>et al.</i> , 2012 ¹¹³	Pre-post surveys	(1) Assess and enhance organizational readiness to adopt information technology, (2) develop a RHIO to share electronic data between medical and ancillary care providers, (3) implement the RHIO and begin active information exchange and (4) evaluate the effect of the intervention on provider-related attitudes and satisfaction with information exchange	North Carolina	Ambulatory HIV providers and ancillary care providers	HIV patient data and lab results	2010	Carolina HIV information cooperative regional health information organization (CHIC RHIO)

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Merrill, <i>et al.</i> , 2013 ¹³⁷	Lab results and other information for rapid and efficient identification, monitoring, investigation, and treatment of communicable and emerging diseases	August 2007-August 2011	Not described but patients who would be reported to the health department for risk and disease.	NR	NR	NR
Messer, <i>et al.</i> , 2012 ¹¹³	1 large academic medical center and 5 AIDS service organizations. Used CAREWare from HRSA. Federated, query-based exchange	2008 organization begun	HIV care providers and ancillary service providers	1 large academic medical center and 5 AIDS service organizations mostly providing case management. Interviews and assessment with 39 stakeholders; pre and post survey of 29 providers' satisfaction with HIE, relationships with other providers, barriers.	Leaders of the individual organizations, HIV providers	NA

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Merrill, <i>et al.</i> , 2013 ¹³⁷	NA	Descriptive narrative only	NA	NA	NA
Messer, <i>et al.</i> , 2012 ¹¹³	NA	<ul style="list-style-type: none"> -Organization readiness for Charge measure -Qualitative process summary -Provider surveys of effectiveness 	NA	NA	Descriptive

Author, year	Results
Merrill, <i>et al.</i> , 2013 ¹³⁷	Three casual loop diagrams captured well recognized system dynamics: Sliding Goals, Project Rework, and Maturity of Resources. The findings were associated with specific policies that address funding, leadership, ensuring expertise, planning for rework, communication, and timeline management.
Messer, <i>et al.</i> , 2012 ¹¹³	<ul style="list-style-type: none"> -Organizational readiness assessment found organizations were well prepared to adopt new technology, in the 4 domains (motivation, adequacy of resources, staff attributes, and org climate) only motivation was slightly below nationally determined levels. Results were consistent by agency type and respondent type -Largely positive response to quality process. Improved sense of mission, more contact with other agencies, better awareness of other agency roles. -Providers found increased case manager knowledge of medical care -Concerns: Initial concerns about confidentiality dismissed over time as trust was built; Respondents noted it is important to manage expectations upfront; Clinic staff must use 2 systems the EHR and CAREWare which takes effort and increases errors; There was an unmet need for training for report generation -Quantitative provider survey: AIDS service organizations and medial providers generally both felt increased ease of data exchanged and that patient care improved. For AIDS service organizations 7/8 satisfaction related questions improved statistically from pre-post, in clinic survey 4/8 improved statistically

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Miller, 2012 ¹²³	Qualitative	Assessed how well 5 diverse California health care entities' HIE capabilities, policies, and procedures satisfied the patient and consumer principles as of early 2011.	California	A captivated integrated delivery system (Kaiser); a physician management service organization (Nautilus); a large public hospital; a large Medicaid HMO; a regional HIE organization	EHR, Patient portal, HIE, administrative, inpatient, outpatient. Patients' medications, allergies, chronic disease diagnoses, history, and lab results. Providers could also view hospital radiology reports.	August 2010-April 2011	1 capitated integrated delivery system (Kaiser); a physician management service organization (Nautilus); a large public hospital; a large Medicaid HMO; a regional health information exchange organization
Miller and Tucker 2014 ¹⁴⁵	Cross-sectional survey, logistic regression	How does size of user (hospital health system or network) affect HIE usage?	U.S.	Health systems and networks	Hospital Electronic Health Record Adoption Database (AHA, funded by ONC and is intended to be the most comprehensive and representative survey of the state of healthcare IT)	2007-2009	Various

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Miller, 2012 ¹²³	Each of the 5 systems had their own HIE. Some used EPIC, Next Gen, Siemen's NetAccess, Axoloti's Elysium HIE software	NR	NR	N=5 organizations; 23 interviews with 18 people	NR	NR
Miller and Tucker 2014 ¹⁴⁵	Various, within-system and out-of-system HIE	Various	U.S.	430 hospital systems, 4,060 hospitals; average system contains 6 hospitals and operates in just under 4 regional markets	NR	None

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Miller, 2012 ¹²³	They compared against 9 principles e.g., important benefits for individual health; important benefits for population health; inclusivity and equality; etc.	Discussed each principle and how well it was met	NA	NA	Descriptive
Miller and Tucker 2014 ¹⁴⁵	NA	Self reported internal or external exchange of data by hospitals	System's size, defined as the number of hospitals owned, leased, sponsored or contract-managed by a central organization	Patient flow, insurance status (Medicaid, Medicare fractions) per capita payroll, physician relationship (independent practice association, group practice, integrated salary model); profit/nonprofit status; specialty vs. general; IT vendor (HIE capability), EMR age	Unit of analysis is hospital, logistic regression p (exchange) = system size, etc.

Author, year	Results
Miller, 2012 ¹²³	Discussed each principle. Also discussed challenges and barriers.
Miller and Tucker 2014 ¹⁴⁵	<p>68% do internal exchange: HIE increases with system size; each additional hospital in system increases likelihood by 2 percentage points; increase if nonprofits, decrease w/ more Medicaid, Medicare, unaffected by location in U.S., age of technology, vendor</p> <p>17% do external exchange: larger hospital systems are less likely to exchange information externally. Each additional hospital in a system lowers the chance of external data exchange from hospitals in that system by 0.7 percentage points. Not affected by relative number of outside hospitals; more sharing with number of beds, number of doctors, % Medicare, per capita payroll; regardless of age of system or size of vendor</p> <ul style="list-style-type: none"> -Robust to type of data (demographic or clinical); -No relation to HMO, PPO, etc.; -Same effects stronger with higher per capita salaries, suggesting some strategic benefit

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Moore, <i>et al.</i> , 2012 ⁹¹	Description	To describe the status and lessons learned from the development and establishment of an HIE based system to alert ambulatory providers when their patients are admitted or discharged from the hospital or ED.	New York City	Hospital, ED, and out patient	System logs	November 1, 2010-April 30, 2011 (6 months)	New York Clinical Information Exchange (NYCLIX)
Myers, <i>et al.</i> , 2012 ¹¹⁷	Mixed methods: survey and interviews during site visits	Describe how members of HIV patients' care teams perceived usefulness and ease of use of newly implemented, innovative HIEs in diverse HIV treatment settings.	Urban settings and 1 suburban setting in New York, New Jersey, Louisiana, California, North Carolina	Hospital specialty clinics, support services, primary care clinics, testing sites, ED, outpatient and inpatient clinics, Office of Public Health, insurers, laboratory and pharmacy services	Laboratory, diagnostic, medical, and service utilization; referrals; and ancillary care support, such as case management, counseling and testing, transportation, and substance use and mental health services	July 2008-December 2010	5 ⁺ HIEs that were part of the Information Technology Networks of Care Initiative that included Bronx-Lebanon Hospital Center, Duke university; hospitals, the city of Paterson, Louisiana State University Health Care Services Division, NY Presbyterian Hospital, St. Mary Medical Center Foundation. Query-based

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Moore, <i>et al.</i> , 2012 ⁹¹	<p>-An event detection and notification system based on a RHIO including major medical centers, primary care physicians, a home health care agency, long-term care facilities and a Medicaid managed care plan</p> <p>-NYCLIX uses a federated architecture in which the clinical repository is spread over a collection of "edge servers" that reside in each of the members' data centers.</p> <p>-Alerts are considered 1-to-1 communication between providers and are limited to name, date and location of service, so patient consent was not required</p>	November 2009	63,305 patients enrolled from 3 hospitals	NR	NA	NA
Myers, <i>et al.</i> , 2012 ¹¹⁷	5 HIEs, each site designed, tailored, and implemented enhancements to existing HIEs according to local needs	NR	Members of HIV patient care teams	60 case workers, medical providers, nonclinical staff. 62 of 102 responded (62%)	Medical providers, case managers and nonclinical members of the participating HIE organizations	NR

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Moore, <i>et al.</i> , 2012 ⁹¹	NA	Number of events detected overall and per patient	NA	NA	Description
Myers, <i>et al.</i> , 2012 ¹¹⁷	Comparison by type of responder	-10-item perceived ease of use -10-item perceived usefulness	Role	NR	<p>Quantitative: Descriptive statistics of individual questions stratified by role and analysis of variance comparison by role</p> <p>Qualitative: Framework Analysis of the qualitative data interviews were organized</p>

Author, year	Results
Moore, <i>et al.</i> , 2012 ⁹¹	<ul style="list-style-type: none"> -42,818 events detected, on average 238 per day -≥1 event: 6,913 patients -1 event: 1,879 patients -≥10 events: 623 patients -Mean events of inpatients who had an event: 7.7 events -Mean events of all patients: 0.7 events
Myers, <i>et al.</i> , 2012 ¹¹⁷	<p>Quantitative: vs. medical providers (57%) and case managers (39%) nonclinical staff members (12%) were significantly less likely to report that they provided input into the design of the HIE (p <0.008). Mean composite for ease of use was high (3.9/5.0) and no difference by role. Mean composite for usefulness was also high (4.0/5.0) and no differences by role.</p> <p>Qualitative: adoption of the HIEs and perceptions of its use and usefulness varied by occupational role of the patient-care team. Also noticed that case workers outside the clinic used the HIE routinely. Those within clinics used HIE sporadically.</p>

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE
Nagykaldi, <i>et al.</i> , 2014 ⁴⁰	Pre-post	Describe a pilot study on a more sophisticated architecture that may provide a preliminary roadmap for building HIE with intelligence.	Central Oklahoma	30 primary care practices, several specialty practices, and the Norman Physician Hospital Organization including an academic hospital and 11 other major hospitals.	Specialty referrals, hospital admissions, prescriptions, laboratory imaging results, and emergency care	March 2010-June 2012	exHUB SMRTnet is a statewide network that includes 120 healthcare organizations.
Nykänen and Karimaa, 2006 ¹²⁴	Interviews, observations, usability, and analysis	Factors of success and failure for a regional IS network of hospital and physician offices	Finland	Regional information system for exchange of clinical data between hospital and primary care offices	Study of HIE documents and processes; interviews of users in pilot phase	NR	Regional information system in Finland
Onyile, <i>et al.</i> , 2013 ¹⁰⁸	Geographic analysis	Determine the geographic distribution of patients using the New York metro RHIO	New York	Multiple settings	Ambulatory physician groups, long-term care facilities, a Medicaid managed care plan, the nation's largest home health- care provider and academic medical centers that serve as major referral centers with a total of 7 503 inpatient beds, 341,065 annual inpatient discharge and 540,854 annual ED visits.	Cumulative: 2009-2011 (patients entered by time of study, 2011)	New York Clinical Information Exchange (NYCLIX) - Manhattan based RHIO

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Nagykaldi, <i>et al.</i> , 2014 ⁴⁰	Comprehensive patient registry and clinical decision support tool and reminder system for preventive care and chronic disease management. Preventive Services Reminder System	NR	346 patients from 6 primary practices. Average age 66.3 years, 67.1% female, 20% ethnic minority	346 patients	NR	NR
Nykänen and Karimaa, 2006 ¹²⁴	Not well-described	NR	Pilot users of system	Unspecified number	NA	None
Onyile, <i>et al.</i> , 2013 ¹⁰⁸	NYCLIX - Manhattan based RHIO, ambulatory groups, long term care, home health care, academic health centers, Medicaid managed care plan	March 2009	Patients who visited a NYCLIX facility	3,980,016 patients (after excluding 26,589 with invalid zip code)	In RHIO master patient index	Invalid zip code

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Nagykaldi, <i>et al.</i> , 2014 ⁴⁰	Before and after HIE	<ul style="list-style-type: none"> -Time-motion studies -Complete documentation on preventive screenings and flu vaccinations -Medication reconciliation 	Before and after SMARTnet employed	NR	Descriptive
Nykänen and Karimaa, 2006 ¹²⁴	None	Perform work tasks and how the HIE changes them	Qualitative	NA	Interviews
Onyile, <i>et al.</i> , 2013 ¹⁰⁸	NA	Visited RHIO facility (in master patient index)	Calculated distance from Times Square	NR	Mapped the most current zip code for each unique patient to the appropriate U.S. county, calculated the distance from each zip code to Times Square, mapped with EpiInfo v3.5.3, spatial regressions with SatScan v9.1.1 and RR of visit by spatial cluster

Author, year	Results
Nagykaldi, <i>et al.</i> , 2014 ⁴⁰	<p>All increased significantly (p<0.001 from pre to post)</p> <p>Completed mammograms: 22.1% to 57.1%</p> <p>Recommended colonoscopies: 31.7% to 53.8%</p> <p>Pneumococcal immunization: 39.1% to 50.6%</p> <p>Influenza immunization: 22.7% to 41.7%</p> <p>Medication reconciliation (defined as the ratio of matching practice records and patient reports before and after the HIE implementation): 35.3% (370 of 1047) to 44.9% (468 of 1043)</p> <p>Barriers included: delays and difficulties in collaborating with commercial technology vendors who gave innovation a low priority</p> <p>Facilitators included: strategic planning, shared goals, and establishing communication methods</p>
Nykänen and Karimaa, 2006 ¹²⁴	Quality of design process deemed a success factor. General statement that users experienced better planning of patient care and access to data, but no details given.
Onyile, <i>et al.</i> , 2013 ¹⁰⁸	NYCLIX has representation in all 50 U.S. states, 4 U.S. territories and 57 International standards organization countries. 12.1 visits/ 100 within 30 miles; 0.4 visits/ 100 at 100 miles; 87.7% live within 30 miles of Times Square; "inflection point" where visits are less than 1 per 100 is 80 miles from Times Square; for cluster counties, RR for visit is 14.4; 77.7% of entire U.S. counties represented; more patients from outer boroughs than from Manhattan

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Overhage, Evans and Marchibroda, 2005 ¹⁴¹	Survey	Community readiness for HIE.	U.S.	Various	Web based survey for Connecting Communities for Better Health	2004	Various
Overhage, Grannis and McDonald, 2008 ⁴¹	Cross-sectional, secondary analysis of existing data	Compare the completeness and timeliness of laboratory reporting for public health in manual and electronic systems	Marion County, Indiana	Marion County, Indiana (public health system)	Indiana Network for Patient Care: 9 of 13 hospitals in county, physician practices, laboratories, radiology centers, public health departments	First quarter of 2001	Indiana Network for Patient Care (INPC) automated public health reporting based on LOINC codes
Ozkaynak and Brennan, 2013 ¹¹⁴	Case report	To describe sociotechnical system in terms of social structure determination of technical forms: "how social systems define technology and its usefulness."	Madison, Wisconsin	3 EDs in different systems in same metropolitan area	210 hours direct observations, varied across shifts, in 5 rounds, by 1 or 2 observers (industrial/ systems engineers, nurses,), with informal conversations to enquire and followup, plus 13 open ended HIE interviews	2008-2010	NR

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Overhage, Evans and Marchibroda, 2005 ¹⁴¹	Various	NA	Organizations and individuals who might be interested: 839 (national associations: 110, government agencies: 57, individuals: 117, national organizations: 354, state-focused organizations: 201)	134	NR	NR
Overhage, Grannis and McDonald, 2008 ⁴¹	Indiana Network for Patient Care: 24 hospitals, physician practices, laboratories, radiology centers, public health departments in Indiana	NR	County wide public health	Marion county population	Notifiable condition in eHIE system or in manual system(s)	No match of identifiers
Ozkaynak and Brennan, 2013 ¹¹⁴	Clinicians choose when to use HIE, which is always available	NR	ED clinicians	184 patient care episodes	NR	NR

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Overhage, Evans and Marchibroda, 2005 ¹⁴¹	NA	None	NA	NA	Descriptive - provide only percent
Overhage, Grannis and McDonald, 2008 ⁴¹	Manual public health reporting by physician offices, laboratories (in and out of Indiana) to state and local public health departments, case finding	-Completeness -Timeliness of public health laboratory reporting	Electronic or manual reporting system	NR	Number identified in eHIE vs. number identified by manual reporting, time to reporting
Ozkaynak and Brennan, 2013 ¹¹⁴	NA	-Use of HIE -Views of clinician-users	NA	NA	Inductive iterative analysis, systems engineers, nurses, physician

Author, year	Results
Overhage, Evans and Marchibroda, 2005 ¹⁴¹	<p>-22% in beta stage, 28% in pilot, 28% operational, 22% conceptual; of 64 self-reported operational, only 9 could be verified</p> <p>-5% no organizational structure; 28% "loose affiliation"; 29% had corporate structure; of these 23% hospitals, 16% provider organizations, 10% academic medical centers, 9% dedicated community HIE, 2% public health</p> <p>-Long lists of organizations to be involved, without actual details of roles; clinicians heavily involved in all, leading the way in 24%; architectures 2% PHR, 20% peer to peer, 3% federated, 54% centralized database; 18% not decided; most planned centralized; broad functionality and data inclusion proposed by participants, without specifics about implementation</p> <p>-Standards proposed: 82% ICD-9, 73% CPT4, 38% LOINC, 41% SNOMED, 48% NDC</p> <p>-One third had identified funding; planned funding over 60% external, 45% subscribers</p>
Overhage, Grannis and McDonald, 2008 ⁴¹	<p>Overwhelming positive effect: 4,635 found by eHIE, 944 by manual; for 818 identified by both, eHIE reported 7.9 days earlier on average, across 53 conditions, eHIE found more for all but 3 conditions; 5/18 data items more often present in manual, 10/18 more often present in eHIE; but false matches (4 Ebola); nondisease positives (rubella screen); repeat testing known positives; delayed report till confirmed or typed (Shigella)</p>
Ozkaynak and Brennan, 2013 ¹¹⁴	<p>-184 patient care episodes (10 use the HIE system, about 5%)</p> <p>-2 unexpected uses of the HIE: (1) The HIE was being used mostly for patients only with specific characteristics. (2) The information from the HIE could be used to confront with the patients.</p> <p>-System used mainly for patients with chronic pain to check previous visits (and prescribing); workflow issues interfered; extra time and effort expended when needed,</p> <p>-When the observers asked the reason of use of the system, the reason mentioned by the majority of the interviewed clinicians was to detect drug-seeking behavior</p>

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Park, <i>et al.</i> , 2013 ⁵⁵	Pre-post implementation survey	To assess patients' perception of an HIE which includes patients' preferences regarding information exchange operations, endorsement of the technology, and expected and perceived benefits and concerns about the technology, and to examine the influence of demographic characteristics and HIE experience on patients' perceptions.	South Korea	Tertiary care and affiliated clinics	Surveys (interview pre-, telephone post-)	2008-2009	Korean HIE pilot
Patel, <i>et al.</i> , 2013 ⁸⁰	Survey	To provide national estimates of physician capability to electronically share clinical information with other providers and to describe variation in exchange capability across states and EHR vendor.	U.S.	Out patient	-2011 National Ambulatory Medical Care Survey -Electronic medical record supplement	2011	Several

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Park, <i>et al.</i> , 2013 ⁵⁵	Federated architecture, stores and transfers HL7 CDAs CDA exchanges between referring providers and SUNBH	June 2008	All patients visiting tertiary hospital and affiliated clinics	Pre: 322 hospital + 408 clinic; Post: 306 of 536 HIE participants, 180 offline information exchange, 208 referral letter only	Not explicitly stated (visited hospital or clinic)	Not explicitly stated
Patel, <i>et al.</i> , 2013 ⁸⁰	Varies	Varies	Nonfederal office-based physicians who provide direct patient care	4,326 respondents (61% weighted response rate)	Out patient MDs	Federal physicians

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Park, <i>et al.</i> , 2013 ⁵⁵	1) paper based, offline (USB stick) and online (HIE); 2) participants and non participants,3) before and after implementation	<ul style="list-style-type: none"> -Need for HIE -Experience with HIE -Preferences -Endorsement -Perceived benefits and concerns -Satisfaction 	HIE exposure status (pre, post, offline, letter)	Demographics	Descriptive, MANOVA
Patel, <i>et al.</i> , 2013 ⁸⁰	NA	Reported capacity for exchange of pharmacy, lab and clinical summary information	<ul style="list-style-type: none"> -State -Physician demographics -Physician use of EHR -Practice characteristics -EHR vendor 	NA	<ul style="list-style-type: none"> -t-tests -Profit regression models

Author, year	Results
Park, <i>et al.</i> , 2013 ⁵⁵	<p>-Group A (offline 'HIE') older, more likely to have operation, inpatient care; 14% used USB, etc., 10% paper HIE; only 23% concerned MD do not know about prior care; all preferred consent based HIE, 80% in HIE, 55-59 in non-HIE;</p> <p>-Post: satisfied, would recommend: 92% of HIE, 88% of non HIE; HIE and offline 'HIE' equally cited convenience, expedited care; all endorsed HIE, HIE group most strongly; all cited convenience, expedited care, HIE group most strongly; HIE group less concerned about privacy, complexity, inconvenience</p> <p>- A higher percentage of HIE patients (80%) compared with A(55%) & B(59%) reported their preferred method of information exchange was HIE</p> <p>-In general those who experienced HIE had statistically higher rates of agreement with survey questions regarding need for HIE</p>
Patel, <i>et al.</i> , 2013 ⁸⁰	<p>Overall: 31% could share clinical summaries, of these 76% could both send and receive, 64% of these exchanges were through an EHR vendor and 28% through a hospital-based system. 55% could e- prescribe, 67% could view lab results, 42% could incorporate lab results into EHR.</p> <p>State differences: the capacity to electronically exchange clinical summaries with patients varied from 55% (Minnesota) to 18% (Louisiana). The proportion of physicians who exchange clinical summaries with other providers varied from 61% (Wisconsin) to 15% (Alabama).</p> <p>-Adoption of EHR is strongest practice characteristic associated with exchange capacity, $p < .001$</p> <p>-EHR vendors have a wide range of capacities for exchange: 24% to 77% of MDs report exchange capacity by vendor</p> <p>-Primary care providers were more likely to exchange vs. specialists, age of MD was NS</p>

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Phillips, <i>et al.</i> , 2014 ¹³³	Comparative case study including interviews, site visits, status checks and document analyses	Study 3 RHIOs implementing a public health use case	New York	Any, but this study focused on public health reporting and querying	Semi-structured interviews and review of documentation of RHIO	NR	3 RHIOs in New York state
Pirnejad, Bal and Berg, 2008 ¹³⁴	Qualitative, semi quantitative, formative	How are data integration and data integrity attained in a communication network?	Almere, the Netherlands	Community - hospital interface	Interviews (pharmacist focus); documents, observations of pharmacist work after implementation	2005-2006	Trans-mural exchange of medication data in Almere (TUMA)

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Phillips, <i>et al.</i> , 2014 ¹³³	All types	Varying	Interviews with leaders of the 3 HIEs	NA	NA	None
Pirnejad, Bal and Berg, 2008 ¹³⁴	Medication information exchange community GP/pharmacist with hospital pharmacy; same vendor, different systems, shared server	2005	Hospitalized people in Almere, Netherlands	0 of 115 GPs, 2 of 17 community pharmacists, 4 hospital pharmacists in 1 hospital pharmacy; project lead and 2 managers	None given	None given

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Phillips, <i>et al.</i> , 2014 ¹³³	None	Certification and becoming operational for public health use case	Qualitative	NA	Interviews
Pirnejad, Bal and Berg, 2008 ¹³⁴	Pre-post	Second stage: changes in work, improvement, problems; after network tested, reasons for problems in test results	First stage: study context, medication data communication, information gaps	NA	Grounded theory

Author, year	Results
Phillips, <i>et al.</i> , 2014 ¹³³	2 common factors influenced risk management and implementation success: leadership capable of agile decision-making and commitment to a strong organizational vision
Pirnejad, Bal and Berg, 2008 ¹³⁴	<p>-Pitfalls and information gaps in the old medication data communication: missing medication information on admission, delay in information at discharge, dependence on patients for prescription information</p> <p>-TUMA effect on bridging the information gaps and improving the communication, focusing on the test results and their analysis.</p> <p>-Important unforeseen problems: (a) technical challenges in system interface (though same vendor); (b) data integrity problems (59 errors in 32/100 records before fix, 55 items in 14/100 records after fix); (c) problems with coding system and its application, with software and its application, (d) and conflicts related to the articulation work and responsibility distribution between the involved parties - e.g. coding differences by GPs and pharmacists</p> <p>-Aim was to replace patient as weakest link - learned that instead "contribution of patients in saving the integrity of data and in integrating medication data is valuable"</p>

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Ross, <i>et al.</i> , 2010 ¹²⁵	Case study approach using telephone and on-site guided discussions	Elucidate perspectives of clinical and administrative leaders in smaller ambulatory practices regarding desired HIE functions, key motivators, barriers to and potential incentives for adoption.	Colorado	SNOCAP-USA Practice-based Research Networks; small to medium-sized practices (<20 providers) in primary care practices	Topic guide created based on literature	November 2008-April 2009	<ul style="list-style-type: none"> 1) Community-wide HIE - currently exchanged information, but could use paper or electronic medical records; 2) Paper charts only - No use of community-wide HIE; 3) EMR only - No use of community-wide HIE.

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Ross, <i>et al.</i> , 2010 ¹²⁵	<p>2 types of community-HIE:</p> <p>1) traditional RHIO that provides limited EMR functionality that includes storage and retrieval of tests, dictations, meds, allergies, e-prescribing (2 urban (1 indigent clinic; 1 private clinic), 1 rural site (private clinic); 22 providers total).</p> <p>2) nontraditional HIE-one EMR across multiples sites in an independent practice association (still met investigators definition of HIE); (1 suburban site; private; 16 providers).</p> <p>Patterns included: 1) bulk of info exchanged was related to ordering tests and studies and receiving results from hospitals and independent labs; 2) vital to exchange info with hospitals and specialty practices (consultation reports and discharge summaries).</p>	NR	Family practice sites participating in SNOCAP-USA practice based research network	Purposeful sampling	Family practice sites participating in SNOCAP-USA practice based research network	None listed

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Ross, <i>et al.</i> , 2010 ¹²⁵	Paper chart only practices and EMR only practices vs. community HIE practices	<ul style="list-style-type: none"> -Desired HIE functions -Key motivators -Barriers to and potential incentives for adoption 	Practice group	None listed	Qualitative analysis was iterative, allowing for investigator corroboration, triangulation, and checking; then coding and theming, creation of briefing sheet, then use of modified Delphi method to finalize analysis. Sites also reviewed and corrected reports prior to final report creation.

Author, year	Results
Ross, <i>et al.</i> , 2010 ¹²⁵	<p>Desired functions of HIE: Universally valued was improved ability to receive and review clinical info from outside the practice; this much more so than improved ability to send or make available info from inside the practice. Paper- and EMR-only anticipated little value in sharing their data with others, but HIE practices realized the value of having their data available anytime/from anywhere. There was consensus that community hospitals and independent lab info would be essential. Also highly desirable to include exchange with specialists. Test results considered most important; followed by discharge summaries.</p> <p>Mean ranking of potential HIE functions (1=highest; 5=lowest rank): looking up info 1.9; delivering results 2.2; e-prescribing 2.5 (lack of computers in exam rooms was a barrier for this one); placing nonprescription orders 3.8; creating reports 4.7; secure email was a lower priority.</p> <p>Essential attributes of HIE: solid reliability and responsive service; live and direct technical support; comprehensive policies and systems for privacy, security and data use</p> <p>Motivations for adopting HIE: motivated to gain uniformity in workflow; improved efficiency (even though did not anticipate monetary benefit; improved quality of care through better coordination and information;</p> <p>Barriers and facilitators:</p> <ol style="list-style-type: none"> 1) Barrier: technical-need to interface with existing systems 2) Barrier: workflow issues-most sites did not want to re-engineer workflow 3) Best facilitator: technical assistance for implementation & maintenance; and training 4) Barrier: financial issues; secondary, but important; capital costs were barrier; not concerned with loss of revenue 5) Facilitators: solidarity & trust were important (easier in smaller cities); wanted involvement by practice leaders, NOT health plans; neutral about government, foundations 6) Practices thought they could education patients to have trust

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Ross, <i>et al.</i> , 2013 ⁴²	Cross-sectional analysis Retrospective cohort	Does HIE affect laboratory and radiology test ordering	Mesa County, Colorado	Physician offices - outpatient	Claims data	April 2005-December 2010	Quality Health Network
Rudin, <i>et al.</i> , 2009 ¹²⁶	Semi structured interviews	What are providers' decision-making processes in implementing HIE?	Massachusetts	Physician offices	Semi-structured interviews	Summer-Fall 2007	Massachusetts eHealth Collaborative (MAeHC)

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Ross, <i>et al.</i> , 2013 ⁴²	Query-based and directed	2005	Claims for 34,818 patients served by 306 providers in 69 practices who had access to the HIE	Claims for 34,818 patients	All having access to HIE	None
Rudin, <i>et al.</i> , 2009 ¹²⁶	Hybrid HIE	NR	Members of MAeHC collaborative and physician users	14 key informants	All interviewed	NA

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Ross, <i>et al.</i> , 2013 ⁴²	Rates of laboratory and radiology testing for primary care and specialist care physicians	-Rates of laboratory and radiology testing -Economic	Rates of laboratory and radiology testing	None	Mixed effects regression model
Rudin, <i>et al.</i> , 2009 ¹²⁶	Technical HIE architecture chosen	Technical HIE architecture chosen	NA	None	Semi-structured interviews

Author, year	Results
Ross, <i>et al.</i> , 2013 ⁴²	For PCPs, rate of laboratory testing increased over the time span (baseline 1041 tests/1000 patients/quarter, increasing by 13.9 each quarter) and shifted downward with HIE adoption (downward shift of 83, p<0.01). For specialist providers (baseline 718 tests/1000 patients/quarter, increasing by 19.1 each quarter, with HIE adoption associated with a downward shift of 119, p<0.01). Imputed charges for laboratory tests did not shift downward significantly in either provider group. For radiology testing, HIE adoption was not associated with significant changes in rates or imputed charges in either provider group.
Rudin, <i>et al.</i> , 2009 ¹²⁶	To become established, HIE efforts must foster trust, appeal to strategic interests of the medical community as a whole, and meet stakeholder expectations of benefits from quality measurements and population health interventions.

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Rudin, <i>et al.</i> , 2011 ¹¹⁵	Qualitative study of an HIE	What affects clinician use of HIE	Massachusetts	Hospitals and physician offices	Interviews of clinician users and HIE staff	October 2009-February 2010	Massachusetts eHealth Collaborative (MAeHC)
Saff, <i>et al.</i> , 2010 ¹³⁵	Case study	Description of motivation, implementation and use of San Francisco Bay Area HIE	San Francisco Bay Area	5 health organizations; 2,800 MDs; 900,000 patients; numerous labs; several IT vendors	Varying types of clinical and administrative data - varies by site	Each medical center joined the HIE at a different time, dating from 2002	NR
Schabetsberger, <i>et al.</i> , 2006 ¹³⁸	Cohort (system logs)	Describe evolution and use of system, problems.	Tyrol, Austria	Tiroler Landeskrankenanstalten, 6 hospital, 6,000 staff, 1,000 physician, 300,000 outpatient, 70,000 inpatient, 400 medical student health system	Logs	June 2003 and October 2004	Various

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Rudin, <i>et al.</i> , 2011 ¹¹⁵	All nontext portions of medical record. Could link directly from the EHR to existing HIE. Query-based exchange. Consent was 'opt-in'.	Mid-2007	Clinician users and staff who implemented HIE	15 clinicians and 2 HIE staff and 3 administrators	NA	None
Saff, <i>et al.</i> , 2010 ¹³⁵	Each medical center valued the HIE for different reasons; descriptions are provided	NR	900,000 patients in the San Francisco and the East Bay	900,000 patients in San Francisco and the East Bay	None specifically stated; all patients included	None specifically stated; all patients included
Schabetsberger, <i>et al.</i> , 2006 ¹³⁸	(1) Discharge summaries push to GP EHRs as text documents, 92+% electronically (2) Standalone web-based archive of hospital documents for nonaffiliated physician access	May 2002-October 2004	Tyrol, Austria physicians	NR	NR	NR

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Rudin, <i>et al.</i> , 2011 ¹¹⁵	None	Motivators and moderators of use	Qualitative	NA	Interviews
Saff, <i>et al.</i> , 2010 ¹³⁵	None	Lessons learned	Characteristics of each health system; this is a descriptive case study	NA	Descriptive
Schabetsberger, <i>et al.</i> , 2006 ¹³⁸	NA	System use	NA	NA	Descriptive

Author, year	Results
Rudin, <i>et al.</i> , 2011 ¹¹⁵	<ul style="list-style-type: none"> -Motivators were belief in improved quality of care, time savings, and reduced need to answer questions. Cost of care was not listed as a motivator. -Motivation was moderated by missing data, workflow issues, and usability issues (too many clicks required to get to information). -Missing data was attributed contributing providers not "locking their notes" on their EHR. -Patient-related moderators were those who had trouble communicating, multiple comorbid illnesses, and who received care at multiple sites within but not outside HIE. -Clinician-related moderators varied by specialty, use of paper and fax, and integration into workflow. -HIE-related moderators were gaps in data from local nonparticipants, poor usability, and downtimes. -Clinicians varied in how quickly they "locked" data for transfer into HIE.
Saff, <i>et al.</i> , 2010 ¹³⁵	<p>Lessons learned</p> <ul style="list-style-type: none"> -Moved from a competitive to collaborative model -EMR/PHR integration -Extensive testing required to ensure quality of data fit for use -Physician education and engagement required/important
Schabetsberger, <i>et al.</i> , 2006 ¹³⁸	<ul style="list-style-type: none"> -6% to 8% of approximately 40,200 discharge letters were sent out electronically -Problems: corrupt data in physician database; differing implementations of standards (EDIFACT standard); independent, nonfederated patient index; 4 GPs and the psych ward had security concerns

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Shapiro, <i>et al.</i> , 2013 ⁴³	Retrospective analysis of clinical data	Measure incremental increase in number of frequent ED users identified when data from all EDs (using HIE) were compared with use of site-specific data only	New York City	10 hospitals that participated in NYCLIX	NYCLIX data (which also included data from site-specific EMRs)	June 1, 2010-May 31, 2011	10 hospitals that participated in New York Clinical Information Exchange (NYCLIX); NYCLIX is a RHIO in NY City; data sent to NYCLIX by each participant organizations; master patient index links each patient across sites; NYCLIX staff was 'honest broker' and provided data.
Sicotte and Paré, 2010 ¹²⁷	Qualitative study, interviews, to inform 2 longitudinal case studies	Describe the implementation and deployment of 2 large HIE projects.	Quebec, Canada	Case 1: 3 pediatric hospitals. Case 2: Primary care network linking a public hospital to 10 private clinics.	52 interviews (27 for Case 1, 25 for Case 2); all documents from the HIE project team, HIE organizations and vendors; and observations at HIE project meetings	January 2001 + 42 months (Case 1); May 2001 + 32 months (Case 2)	Case 1: 3 pediatric hospitals. Case 2: Primary care network linking a public hospital to 10 private clinics.

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Shapiro, <i>et al.</i> , 2013 ⁴³	New York Clinical Information Exchange (NYCLIX)	NR	All patients with ≥1 instance of ≥4 ED visits within 30 days during study period	924,675 ED visits by 591,632; 920,507 ED visits by 591,632 patients	All patients with ≥1 instance of ≥4 ED visits within 30 days during study period	4,168 visits because they occurred within 6 hours of a previous ED visit, which investigators decided a priori might represent clerical errors
Sicotte and Paré, 2010 ¹²⁷	Case 1: large pediatric hospital, 2 community pediatric hospital, 4 pediatric clinics. Case 2: public hospital, over 100 physicians at 10 private clinics. Access to laboratory and imaging results.	Specific date unclear	Key informants description limited to HIE project staff and HIE users	52 interviews (27 for Case 1, 25 for Case 2)	NR	NR

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Shapiro, <i>et al.</i> , 2013 ⁴³	EMR use without accessing HIE	<ul style="list-style-type: none"> -Number ED visits -Number of patients experiencing these visits -Average number ED visits per patient during 12 months -Number patients frequent ED users (per definition) -Number of ED visits accounted for by frequent users -Average number visits per frequent user -Increase in number of frequent users when estimated across HIE (vs. within each site) 	<ul style="list-style-type: none"> -Gender -Age 	Cross-over visits (different EDs)	<ul style="list-style-type: none"> -Chi² -Wilcoxon sign rank test
Sicotte and Paré, 2010 ¹²⁷	NA	Descriptive narrative only	NA	NA	Empirical observations were organized into narrative using a risk analysis framework

Author, year	Results
Shapiro, <i>et al.</i> , 2013 ⁴³	<p>Total visits: 924,675 (591,632 unique patients) After exclusion: 920,507 visits by 591,632 patients Mean ED visits/year: 1.6 When used only site-specific data only: 4,786 patients met criteria of frequent user (represented 0.8% of all users) Number of ED visits: 45,771 Mean visits/years: 9.6 (accounted for 5% of ED visits)</p> <p>HIE-wide results 5,756 frequent ED users 20% increase in number of frequent user events identified 53,031 visits (6% of all ED visits) Thus HIE data produced 16% increase in number ED visits that could be identified Frequent users more likely to be male: 51% vs. 45%, p<0.0001 Mean age higher: 40.7 vs. 37.9 years, p<0.0001 More had cross-over visits: 28.8% vs. 3%, p<0.0001</p>
Sicotte and Paré, 2010 ¹²⁷	<p>Case 1: 4 stages described: project planning with small part-time team; technical system with risks evolving; testing requiring de-scoping; piloting with user and technical challenges. Overall deliverable not reached, users discouraged and usage was low.</p> <p>Case 2: 4 stages described: project planning with full-time staff, system integrator consultant and clinical champions; solicitation of user views and realistic understanding of context, participant contracts signed; system customization and testing, leveraging super-users; piloting, troubleshooting system performance issues. Overall view was successful with high usage.</p>

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Silvester and Carr, 2009 ⁹⁹	Quasi-experimental (pre-post)	Description of implementation - use of system.	Brisbane & Northern Territories of Australia	239 GPs from 66 practices, 2 major public hospitals, 3 large private hospitals, 11 allied health/ community based partners	Registration, communication, and clinical database. Clinical database contains socioeconomic status, medications, diagnosis, allergies, medical history, diagnostic results, care team members, unstructured documents	April 30, 2007-July 2008	Name NR 239 GPs from 66 practices, 2 major public hospitals, 3 large private hospitals, 11 allied health/community based partners
Soderberg, Laventure and Minnesota, 2013 ⁷⁹	Survey	To monitor progress toward meeting the legislative requirement that all health care providers have an interoperable EHR by 1/2015.	Minnesota	Clinics	72 survey questions	February 15-March 15, 2013	Varies
Steward, <i>et al.</i> , 2012 ¹²⁸	Qualitative	Understand the dynamic capabilities that enabled the 6 demonstration projects of the Information Technology Networks of Care Initiative to	New York, New Jersey, California, Louisiana, New York	Hospital specialty clinics, support services, primary care clinics, testing sites, ED, outpatient and inpatient clinics, Office of Public Health, insurer, laboratory and pharmacy services	Laboratory, diagnostic, medical, and service utilization; referrals; and ancillary care support, such as case management, counseling and testing, transportation, and substance use and mental health services.	NR explicitly but at 2 points in time: as the HIE were being developed and 1-2 years after the HIE became operational.	6 HIEs that were part of the Information Technology Networks of Care Initiative that included Bronx-Lebanon Hospital Center, Duke university; hospitals, the city of Paterson, Louisiana State University Health Care Services Division, NY Presbyterian Hospital, St. Mary Medical Center Foundation

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Silvester and Carr, 2009 ⁹⁹	Software developed by HealthConnect; web services, HL-7 messaging, extracts data from clinician's software package, interfaces seamlessly with clinician's software, uses Medicare Australia's public key infrastructure security certificates for authentication; patients 'opt-in'.	Prior to April 30, 2008; implemented iteratively to ensure success	Registered patients with chronic conditions, cared for at these sites	1,108 patients in population	None, other than stated in population and sample	None, other than stated in population and sample
Soderberg, Laventure and Minnesota, 2013 ⁷⁹	Varies	Varies	1,623 ambulatory clinics	The response rate was 79%, with 1,286 clinics responding	Any location where primary or specialty care ambulatory services are provided for a fee by ≥1 physician	NR
Steward, <i>et al.</i> , 2012 ¹²⁸	Each of 6 projects implemented a different HIE.	NR	111 project staff and IT specialists; staff from community-based organizations and public health organizations; users of HIE.	NR	NR	NR

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Silvester and Carr, 2009 ⁹⁹	Before implementation	-Frequency of use (number of events uploaded per patient) -User access logs and patient registration growth rates and connection metrics -User surveys -Patient case studies	None	None	-Descriptive summaries -Qualitative analysis
Soderberg, Laventure and Minnesota, 2013 ⁷⁹	None	Exchanges with affiliated and unaffiliated hospitals	NA	NA	Frequencies
Steward, <i>et al.</i> , 2012 ¹²⁸	Cross-site evaluation	Implementation outcomes	NA	NA	-Qualitative: developed 16 coding topics -Convergent and divergent perspectives examined within and across sites

Author, year	Results
Silvester and Carr, 2009 ⁹⁹	<ul style="list-style-type: none"> -Mean events uploaded for each patient record during 12 months: 9.7 -Increased HIE use by nurses -Number of patients registered increased: 474 (July 2007) to 1,320 (June 2008) -Increased commitment to use -Case studies demonstrated use prevented unplanned inpatient admissions -Interest to adopt by others <p>Improved staff perceptions in answers to 3 pre-post questions on 5-point Likert scale</p> <ul style="list-style-type: none"> Improved understanding of system: 2 to 3 Improved sharing of information: 2 to 2.3 Impact on care delivery: 3 to 3.6 <ul style="list-style-type: none"> -2 patient-specific case studies showed improved use, communication, satisfaction -Lessons learned included connectivity, interoperability, change management, clinical leadership, targeted patient involvement, information at point-of-care, and governance
Soderberg, Laventure and Minnesota, 2013 ⁷⁹	<ul style="list-style-type: none"> -54% exchange data with affiliated hospitals -36% with unaffiliated hospitals -Common challenges for HIE: limited capacity of others to exchange, lack of technical support or expertise, competing priorities, cost and privacy concerns
Steward, <i>et al.</i> , 2012 ¹²⁸	<p>Found evidence for importance of 3 dynamic capabilities: information systems, reconfiguration capacity, and organization size and human resources. Reconfiguration capacity was most important.</p>

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Thorn, Carter and Bailey, 2014 ¹¹⁶	Qualitative	To explore views of emergency physicians having access to HIE, about their access of and use of HIE data	NR	ED in 4 hospitals, private and public settings	Individual unstructured interviews, audio recorded and transcribed	NR	HIE name NR but may be MSeHA Regional HIE operational for 4 years, linking over 450 providers in 15 clinics and 9 major hospitals serving a population of 1 million
Tripathi, <i>et al.</i> , 2009 ¹⁰⁶	Qualitative description of collaborative decision making; focus groups	Description of initiative, collaborative design and lessons learned; also includes opt in data by consumer	Massachusetts	3 communities chosen to pilot HIE, Brockton (diverse community), Newburyport (affluent), North Adams (rural)	Community steering committees, MAeHC, stakeholders; consumer focus groups	Began in 2005 Duration not clear	Massachusetts eHealth Collaborative (MAeHC)
Tzeel, Lawnicki and Pemble, 2011 ⁴⁴	Observational retrospective cohort	Assess the association of HIE use on health care costs	S.E. Wisconsin (Milwaukee County)	EDs in 5 health systems in a county	WHIE data - health plan member with ED encounter when HIE access occurred. Humana claims data - costs and utilization of ED encounter.	December 2008-March 2010	Wisconsin Health Information Exchange (WHIE)

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Thorn, Carter and Bailey, 2014 ¹¹⁶	Data in HIE NR Decentralized, query-based exchange. Consent was 'opt-out'	NR	ED physicians in 3 urban settings	N=15 physicians from 4 urban hospital systems having <10% usage of HIE. Cross section of public and private hospitals. 1 Level I Trauma center. 2 of 4 settings had not implemented EHRs	Full or part-time physicians working regularly scheduled ED shifts. Purposeful selection of 2 because of a 4-year history of HIE use. Rest recruited with "theoretical sampling"	NR
Tripathi, <i>et al.</i> , 2009 ¹⁰⁶	NR	NR	Number of participants in committees and stakeholders involved not stated	NA	NA	NA
Tzeel, Lawnicki and Pemble, 2011 ⁴⁴	Links 5 health systems in the county. Access to patient demographics, chief complaint, allergy, primary care provider, diagnosis, meds, procedures, encounter date & location.	December 2008	Commercial, fully insured members of Humana health plan (denominator); members in the WHIE database having ≥2 ED visits	Test group: 428 members with ED visits having an HIE query Control group: 1,054 members with ED visits with no HIE query. Propensity score matching for test group (N=326) with HIE database query in all ED visits vs. control group (N=325) with HIE database query in all ED visits vs. control group (N=325) with HIE database not queried in any ED visit.	≥1 year continuous insurance coverage with health plan	<6 months coverage before program started or <3 months after start of program

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Thorn, Carter and Bailey, 2014 ¹¹⁶	NA	Descriptive narrative only	NA	NA	Constant comparative analysis of narrative
Tripathi, <i>et al.</i> , 2009 ¹⁰⁶	NA	<ul style="list-style-type: none"> -Descriptive narrative only -Type of patient consent -Type of data to share 	NA	NA	NA
Tzeel, Lawnicki and Pemble, 2011 ⁴⁴	Pairs matched for age, gender, and costs for net care per participant per month prescriptions, inpatient, outpatient, ED, and physician.	<ul style="list-style-type: none"> -Comparison of net costs and ED costs per participant -Comparison of top 5 ED procedures in test group vs. matched control 1 year before and 1 year after the first ED visit 	Pairs matched for age, gender, and costs for net care per participant per month prescriptions, inpatient, outpatient, ED, and physician	NR	Matched pairs t-tests

Author, year	Results
Thorn, Carter and Bailey, 2014 ¹¹⁶	<p>Themes</p> <ul style="list-style-type: none"> -Users varied in their HIE use. Stated influencers including trouble accessing system, acuity of patient or history not available, team members' ability to access. -HIE use affected decisions sometimes, for specific cases (e.g. drug seekers); often HIE use did not affect decisions -Use was negatively affected by access challenges, separate login, variability in data being pertinent, absence of data types or data on specific patients, user design flaws, and lack of technical support. -Benefits with usage included reducing redundant testing, more accurate history, reducing faxing, knowledge of primary care provider name -Barriers to usage included continued practice of defensive medicine, desire for autonomy, changing the culture, belief HIE does not alter decisions, health system competition, and reduced revenue, workflow disruption.
Tripathi, <i>et al.</i> , 2009 ¹⁰⁶	<p>Discussion of experience/lessons learned</p> <ul style="list-style-type: none"> -Decision on consent: opt in chosen due to state law stricter than federal HIPAA law; use of a centralized data repository; and consumer feedback. -Data shared: 3 communities agreed on what to share - all EHR except text notes, consult letters and scanned reports. -Consumer focus groups identified themes to drive HIE/opt in: promote convenience and costs, promote with providers, say benefits up front, confront risks, use professional marketing -Consumer opt In across 2 smaller communities: 88% and 92%
Tzeel, Lawnicki and Pemble, 2011 ⁴⁴	<p>Unadjusted: ED costs in test group changed \$1,068 to \$999 from 1st to subsequent visit vs. control group changed \$1,043 to \$1,157</p> <p>Adjusted for propensity matching: Net costs (per participant per month) in test patients with higher net costs overall in and subcategories</p> <p>ED costs: \$29 less in test patients from first visit vs. subsequent visits.</p> <p>Top ED procedures: 4 of 5 were reduced in test group (lab, radiology, CT, EKG)</p>

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Tzeel, Lawnicki and Pemble, 2012 ⁴⁵	Observational retrospective cohort	Assess the association of HIE use on hospital admissions	S.E. Wisconsin (Milwaukee County)	EDs in 5 health systems in a county	WHIE data - health plan member with ED encounter when HIE access occurred. Humana claims data - costs and utilization of ED encounter.	December 2008-March 2010	Wisconsin Health Information Exchange (WHIE)
Unertl, <i>et al.</i> , 2013 ¹³⁶	Qualitative	To investigate how technology and health system coevolve to reduce information fragmentation and improve care coordination (Extension of Unertl 2012 study)	Memphis, Tennessee region	6 EDs and 8 ambulatory clinics	Direct observation at 14 sites, informal interviews at sites, 9 semi structured telephone interviews	January-August 2009	MidSouth eHealth Alliance (MSeHA), regional HIE around Memphis includes majority of large hospitals and 2 safety net clinic systems.
Unertl, Johnson and Lorenzi, 2012 ¹⁰⁴	Qualitative	To understand the interaction between HIE and workflow. How have sites integrated HIE into existing approaches? Are there common HIE workflow patterns across sites? How do providers incorporate HIE into clinical practice?	Memphis, Tennessee region	6 EDs and 8 ambulatory clinics	Direct observation (180 hours) at 14 sites, informal interviews at sites, 9 semi structured telephone interviews with physicians, nurses and IT management	January-August 2009	MidSouth eHealth Alliance (MSeHA), regional HIE around Memphis includes majority of large hospitals and 2 safety net clinic systems.

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Tzeel, Lawnicki and Pemble, 2012 ⁴⁵	Links 5 health systems in the county. Access to patient demographics, chief complaint, allergy, primary care provider, diagnosis, meds, procedures, encounter date & location.	December 2008	Commercial, fully insured members of Humana health plan (denominator); Members in the WHIE database having at least 2 Emergency Dept. (numerator) was the study population.	Test group: 428 members with ED visits having an HIE query Control group: 1,054 members with ED visits with no HIE query Matched pairs: 325	≥1 year continuous insurance coverage with health plan	<6 months coverage before program started or <3 months after start of program
Unertl, <i>et al.</i> , 2013 ¹³⁶	HIE structure from Vanderbilt University. Data on >1 million patients includes test results, imaging, discharge summaries, diagnosis codes and claims data. Opt out model.	2004	NR	NA	NR	NR
Unertl, Johnson and Lorenzi, 2012 ¹⁰⁴	HIE structure from Vanderbilt University. Consolidated data from multiple hospital emergency departments and community-based ambulatory clinics. Decentralized, query-based exchange. Data on >1 million patients includes test results, imaging, discharge summaries, diagnosis codes and claims data. Opt out model.	2004	NR	NA	NR	NR

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Tzeel, Lawnicki and Pemble, 2012 ⁴⁵	Pairs matched for age, gender, and costs for net care per patient per month, prescriptions, inpatient, outpatient, ED, and physician.	<ul style="list-style-type: none"> -Admissions per 1,000 members, at time of ED visit (1st, 2nd visit) -Conditional probability of admission at ED visit (1st, 2nd) -Bed days per 1,000 members -Average length of stay 	Pairs matched for age, gender, and costs for net care per patient per month, prescriptions, inpatient, outpatient, ED, and physician	NR	Chi ²
Unertl, <i>et al.</i> , 2013 ¹³⁶	NA	Descriptive narrative only	NA	NA	Open-ended grounded theory analysis, followed by the application of the Information Ecology Framework to structure additional analysis
Unertl, Johnson and Lorenzi, 2012 ¹⁰⁴	NA	Descriptive narrative only	NA	NA	Grounded method using open coding, and framework-focused axial coding.

Author, year	Results
Tzeel, Lawnicki and Pemble, 2012 ⁴⁵	<p>Adjusted for propensity matching</p> <p>Admission/1,000 members (1st to 2nd ED visit): 269 to 664 for test group vs. 321 to 555 for control group Probability of admission higher at 1st ED visit in control group, and higher at 2nd ED visit in test group Test group had 771 fewer bed days/1,000 members and lower length of stay than control group</p> <p>Post-propensity matching analysis showed that test group had 199 more admissions per 1000 members than control group, these admissions might have been more appropriate. Test group admissions resulted in less time spent as inpatients and by average length of stay (4.27 days per admission for all admissions and 0.95 days per admission when catastrophic cases removed).</p>
Unertl, <i>et al.</i> , 2013 ¹³⁶	<p>-All sites had coexisting use of HIE and manual processes to access information</p> <p>-Observations were used to map 5 Info Ecology Framework components to a newly developed "Regional Health Information Ecology": 1. system - HIE to reduce information silos; 2. locality - sites had distinct local context; 3. diversity - staff had varied roles with varied HIE processes; 4. keystone species - info consumers, who used data for varied reasons; info reservoirs, people who played formal and informal roles; exchange facilitators, who assisted others and bridged gap between consumers and reservoirs.</p> <p>-Paradox observed: providers describe HIE useful, regardless of use frequency ("when we use it, it's great"); but, provider belief that HIE not being used to full potential.</p> <p>-Examples of impact were identified using their model: a. reduce fragmentation of information; b. reduce time to obtain information; c. increase provider awareness of patient-health system interactions (e.g., drug seeking)</p>
Unertl, Johnson and Lorenzi, 2012 ¹⁰⁴	<p>Cross organizational patterns; 2 models identified</p> <p>1. Nurse workflow: prompted by patient reporting recent hospitalization event during intake, HIE access by nurse or assistant, printed discharge summary, added to chart</p> <p>2. Physician workflow: HIE accessed by provider (doctor or nurse practitioner) for greater reasons beyond hospitalization; HIE access occurred at various points of care; HIE review of more information including history</p> <p>-Other observations: clerks tracked biopsy results; workflow patterns evolved over time, due to factors such as access policies or staffing changes; residents logged into other EMR due to lack of HIE access</p> <p>-Reasons to access HIE: visit to another hospital; issues of patient trust; communication challenges; referrals</p>

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Vest and Jaspersen, 2012 ⁸⁸	Case control	How does HIE access vary by job type and organization in an indigent care HIE in central Texas?	Austin, Texas	Indigent patients and facilities that care for them	Log files from clinical data repository (Indigent Care Collaboration of Austin, Texas safety network providers founded 1997); 18 hospitals, public and private clinics, government agencies (federally qualified health centers)	January 2006-June 2009	Integrated Care Collaboration (ICC)
Vest, 2009 ⁴⁶	Retrospective cohort	Test the hypotheses that HIE information access reduced ED visits and inpatient hospitalizations for ambulatory care sensitive conditions among medically indigent adults.	Central Texas	18 members in HIE (I-Care): hospital systems, public and private clinics, and governmental agencies operating federally qualified health centers	Demographic, clinical information, diagnoses, medication orders, prior visits, payer sources for uninsured patients.	January 1, 2005-June 30, 2007	18 members in HIE: hospital systems, public and private clinics, and governmental agencies operating federally qualified health centers

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Vest and Jaspersen, 2012 ⁸⁸	Clinical data repository (Indigent Care Collaboration of Austin, Texas safety network providers founded 1997); 18 hospitals, clinics, government agencies (federally qualified health centers)	HIE 1997; I-Care database 2002, 3.1 million encounters, 600,000 individuals	Indigent people, not Medicare	105,705 unique user sessions	User session as all system viewing activity (i.e., screens accessed) by a given user for a given patient on a given date.	Could not classify 35 user sessions (0.03%) and excluded them as too few for meaningful analysis.
Vest, 2009 ⁴⁶	Each site contributes patient electronic data to I-Care through secure electronic interfaces. In turn, each location may access data from I-Care at a secured website.	HIE 1997; I-Care database 2002, 3.1 million encounters, 600 thousand individuals	Uninsured 18 to 64 years old and excluded encounters at the public mental health provider and Planned Parenthood	3463 HIE access, 2651 No access; 6,114 included out of 600,000 individuals, 3.1 million encounters	Uninsured 18 to 64 years old	Encounters at the public mental health provider and Planned Parenthood. Also excluded encounters related to accidents, pregnancy, labor and delivery.

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Vest and Jaspersen, 2012 ⁸⁸	None	Administrative vs. clinical vs. repetitive vs. mixed use	-User types and unique job titles -Workplaces	Same day, within a week, within a month, within a year, longer than a year, or no encounter	Cross tabulation to compare usage categories with A) job categories, B) workplace categories, and C) timing of usage categories. Associations evaluated between types of usage and these variables using the Pearson chi ² test of independence
Vest, 2009 ⁴⁶	Persons with no information accessed in the HIE vs. those with accessed information	-ED visits and inpatient hospitalizations due to ambulatory care sensitive hospitalizations -Logs document the user's location, the patient viewed, the date accessed, and information screen viewed	-Predictors of HIE use (e.g., demographics, number of chronic conditions, prior ED visits or hospitalizations) -HIE for predicting ED and hospitalizations	-Clinical, demographic, comorbidity, service measures -Created a chronic condition index by summing chronic conditions (diabetes, hypertension, asthma, ischemic heart disease, hypercholesterolemia and stroke)	-Frequencies and percent -Multiple logistic regression adjusting for confounders

Author, year	Results
Vest and Jaspersen, 2012 ⁸⁸	<p>->6/10 sessions users accessed the system in a minimal fashion</p> <p>-Average pattern length: 2.89 screens</p> <p>-Shortest pattern length included only 1 screen and the longest pattern involved 83 screens</p> <p>-65.7% of all user sessions had a pattern length of only 2 screens</p> <p>-Use was overwhelmingly (93.9%) administrative, roughly evenly distributed across workplaces but for dominance of hospital accesses (37.6%) and about half same day, a fifth first week, a fifth over the year, 1/10 unassociated with encounter; usage type associated with job category: admin, nurse, pharmacy, physician, public/mental health, social services; most clinical access in ED, and public/mental health</p> <p>-297 users, 113 unique job titles, collapsed into administration (59% of users), nurse (~6% of users), pharmacy (~1% of users), physician (~12% of users), public health (~6% of users), and social services (~15% of users)</p> <p>-Workplaces: ambulatory care (~9% of users), ED (~18% of users), children's ED (3% of users), hospital (53% of users), public health agency (8% of users), or mental health agency (8% of users).</p> <p>-In more than 6 out of 10 sessions, users accessed the system in a minimal fashion.</p> <p>-Average pattern length was 2.89 screens (range 1-83 screens); 66% of all user sessions had a pattern length of only two screens.</p>
Vest, 2009 ⁴⁶	<p>Adjusted OR of HIE information access</p> <p>Increasing age: 1.03; number of chronic conditions: 1.13; ≥1 prior year clinic visit: 1.63; a prior year ED visit: 1.96; and being hospitalized in 2004: 2.02</p> <p>All levels of HIE information access were associated with increased expected ED visits and ambulatory care sensitive hospitalizations vs. no information access</p> <p>-HIE was used more for those that used the system more, or were sicker.</p> <p>-HIE was not accessed for 43% of individuals</p> <p>-Ultimately, these results imply that HIE information access did not transform care in the ways many would expect. Expectations in utilization reductions, however logical, may have to be reevaluated or postponed.</p> <p>-Patients with HIE information accessed one time had an 83% higher expected count of ED visits.</p>

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Vest, 2010 ¹⁴⁶	Survey	Which nontechnological and technological factors may still hamper the existence of effective HIE even in light of the substantial financial incentives offered via the HITECH Act?	U.S.	U.S. Hospitals	2008-2009 HIMSS Analytic Database; AHA Annual Survey 2007	After 2009	Various
Vest and Miller 2011 ⁵⁶	Cross-sectional, regression analysis	Do hospitals using HIE have higher reported communication among health professionals and/or higher patient satisfaction?	U.S.	Hospitals	-2008-2009 HIMSS Analytic Database -AHA Annual Survey 2007 -Review of all HIE facilitating efforts in U.S., linked to HCAHPS survey	After 2009	Various

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Vest, 2010 ¹⁴⁶	Various	Various	U.S.	4,830 hospitals in AHA and HIMSS-AD	In AHA or HIMSS survey	NR
Vest and Miller 2011 ⁵⁶	Various	Various	U.S	3,278 hospitals, 340 adopted, 351 implemented HIE	Participated in AHA or HIMSS survey	Too few observations (HCAHPS survey responses <100)

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Vest, 2010 ¹⁴⁶	Operational vs. adopted not operational vs. not adopted	HIE adoption (operational, implementing, nonadapter)	Technological readiness (number of live applications, CCHIT EMR), vertical integration, horizontal integration, high/low information needs, inpatient admissions, market competition, uncompensated care burden, primary care rate, health system/network size	<ul style="list-style-type: none"> -Classic markers of innovation adoption considered covariates -Total number of beds (size) -Average days cash on hand from all sources -Nonmetropolitan location -General innovativeness was measured both as academic affiliation and specialization, the standardized total number of professional job categories 	<ul style="list-style-type: none"> -Begins with, or assumes, TOE framework: technological, organizational, and environmental; missing values imputed from earlier versions of AHA Guide and HIMSS-AD -Logistic regression on adoption, logistic regression on operational
Vest and Miller 2011 ⁵⁶	Adopted vs. implemented vs. none	<ul style="list-style-type: none"> -Percentage of patients who reported their doctors and their nurses always communicated well -Percentage of patients who would definitely recommend the hospital -Percentage of patients who gave the hospital a high global rating (≥ 9 on a 10-point scale) 	Level of HIE participation: implemented (active sharing); adopted (participating but not yet sharing); or none	Organizational variables associated with HCAHPS outcomes; other AHA organizational characteristics, overall level of automation in hospital, external factors such as state regulations	<ul style="list-style-type: none"> -Least squares regression -Propensity score adjustment

Author, year	Results
Vest, 2010 ¹⁴⁶	<ul style="list-style-type: none"> -59 operational and 123 nonoperational exchanges -453 hospitals operational HIE, 446 adopted HIE, and 3,931 had not adopted HIE; sample includes more general service type and fewer for-profit hospitals than the more nationally representative AHA survey -Overall, 81.4% of hospitals had not adopted or implemented HIE -Adjusted regression OR of adoption for not for profit: 8.57; public: 9.53; number operational application: 1.02; physician portals: 1.38; network membership: 1.33; ED visit: 1.01' primary care MD in HRR: 1.03 -Adjusted regression OR of implementation: network membership: 1.96; hi competition: 0.15; primary care MD: NS
Vest and Miller 2011 ⁵⁶	<ul style="list-style-type: none"> -10.4% had adopted -10.7% had implemented HIE -Implemented hospitals, but not adopted hospitals, had higher nurse communication (0.75 increase [95% CI, 0.13 to 1.38]), global satisfaction (0.82 [95% CI, 0.01 to 1.64]), and would recommend scores (1.34 [95% CI, 0.41 to 2.27]), and a trend toward higher doctor communication scores (NS after controlling for confounders); results attenuated in propensity score analysis -Communication: higher for smaller hospitals, rural hospitals, fewer Medicaid patients, higher nurse/patient ratios -Satisfaction: higher for nonprofit, smaller, Midwest or south, fewer Medicaid patients, higher nursing ratios

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Vest, <i>et al.</i> , 2011 ⁸⁹	Case control	Do hospitalizations, ED visits, and other factors predict HIE use for indigent adults?	Austin, Texas	Indigent patients and facilities that care for them	Log files from clinical data repository (Indigent Care Collaboration of Austin, Texas safety network providers founded 1997); 18 hospitals, clinics, government agencies (federally qualified health centers)	January 2006-June 2009	Integrated Care Collaboration (ICC)
Vest, <i>et al.</i> , 2011 ⁸⁹	Case control	Do hospitalizations, ED visits, and other factors predict HIE use for indigent children?	Austin, Texas	Indigent patients and facilities that care for them	Log files from clinical data repository (Indigent Care Collaboration of Austin, Texas safety net providers founded 1997); 18 hospitals, clinics, government agencies (federally qualified health centers)	January 2006-June 2009	Integrated Care Collaboration (ICC)

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Vest, <i>et al.</i> , 2011 ⁸⁰	Clinical data repository (Indigent Care Collaboration of Austin, Texas safety network providers founded 1997); 18 hospitals, public and private clinics, government agencies (federally qualified health centers)	HIE 1997; I-Care database 2002, 3.1 million encounters, 600,000 individuals	Indigent people, not Medicare	271,305 encounters (111,482 unique patients) from 10 facilities; (Vest 2009 was 3,463 HIE access, 2,651 no access; 6,114 included out of 600,000 individuals, 3.1 million encounters)	All ED encounters among patients ages 18 to 64 that occurred between January 1, 2006 and June 30, 2009	Excluded any ED encounters occurring at facilities before the hospital had an authorized user of the I-Care system.
Vest, <i>et al.</i> , 2011 ⁸⁹	Clinical data repository (Indigent Care Collaboration of Austin, Texas safety network providers founded 1997); 18 hospitals, clinics, government agencies (federally qualified health centers)	HIE 1997; I-Care database 2002, 3.1 million encounters, 600,000 individuals	Indigent people, not Medicare	179,445 encounters	All ED encounters among patients <18 years occurred between January 1, 2006 and June 30, 2009 and had parental consent	Excluded any ED encounters occurring at facilities before the hospital had an authorized user of the I-Care system.

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Vest, <i>et al.</i> , 2011 ⁹⁰	None	No usage vs. basic usage vs. novel usage (more screens)	<ul style="list-style-type: none"> -Familiarity -Complexity -Mental/substance use -Frequency of prior utilization elsewhere -Time constraints 	Assessed with multivariate analysis, otherwise NR	Logistic regression with adjustment for by-patient clustering
Vest, <i>et al.</i> , 2011 ⁸⁹	None	No usage vs. basic usage vs. novel usage (more screens)	3 factors as indicative of uncertainty that creates an information need: comorbidity, prior utilization, and unfamiliarity with the patient	NR	Logistic regression with adjustment for by-patient clustering

Author, year	Results
Vest, <i>et al.</i> , 2011 ⁹⁰	<ul style="list-style-type: none"> -No access of system for 97.7% of encounters -Users accessed the I-Care system for 2.3% of the 271,305 encounters -Basic usage (42,527) 41.1% of instances -Sample was predominately Hispanic, younger, and a higher proportion of charity care recipients -Adjusted OR of access for African American and Hispanic: 0.76 to 0.89; higher for unknown or charity care; but mainly for unknown payer: 4.7 vs. 2.6; access higher for more ED visits; hospitalizations: ~1.25-1.5 (from graph) -Access lower for alcohol use, injury, poisoning, unfamiliar patient, busier than average day
Vest, <i>et al.</i> , 2011 ⁸⁹	<ul style="list-style-type: none"> -System accessed: 15,586 of 179,445 encounters (8.7%) -OR of basic HIE access for >1 year old vs. ≤1 year old: ~1.5 (from graph); lower for race unknown; higher for payer unknown; PC visits within 12 months: ~1.5 (from graph); ED visits within 12 months: 1.5-2 (from graph); hospitalized: 1.3; number of diagnoses: 1.05; unfamiliar: 0.46; busier than average: 0.65 -OR of novel HIE access for >1 year old vs. ≤1 year old: ~1.3; NS for race unknown; higher for payer unknown; PC visits within 12 months: ~2 (from graph); NS for ED visits within 12 months; hospitalized: 1.15; number of diagnoses: 1.05; unfamiliar: 0.19; NS busier than average

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Vest, <i>et al.</i> , 2012 ⁸⁶	Case control	Use of HIE in 2 ambulatory indigent clinics without EHRs, and patient factors associated with this use.	Austin, Texas	2 ambulatory clinics serving indigent people, part of nonprofit hospital system, 10,550-12,250 encounters/year	Log files from clinical data repository (Indigent Care Collaboration of Austin, Texas safety network providers founded 1997); 18 hospitals, public and private clinics, government agencies (federally qualified health centers)	January 2006-June 2009	Integrated Care Collaboration (ICC)
Vest, <i>et al.</i> , 2013 ⁸⁷	Case control	Display and analyze the pattern of radiology report requests among organizations participating in an HIE, and identify the patient and provider factors associated with use of a HIE system to access radiology report	Western New York State	Nonprofit RHIO working with Hospital systems, reference laboratories, radiology groups, insurance providers, and county offices	Log files, RHIO information about job title, job type, and location, and claims data.	The log file was limited to patients 18 years and older and reflected patient encounters from January 2009-March 2011	Rochester RHIO

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Vest, <i>et al.</i> , 2012 ⁸⁶	Clinical data repository (Indigent Care Collaboration of Austin, Texas safety network providers founded 1997); 18 hospitals, clinics, government agencies (federally qualified health centers)	HIE 1997; I-Care database 2002, 3.1 million encounters, 600,000 individuals	Indigent people, not Medicare	39,447 encounters 6,393 patients	Age 19-64 years Austin metro area, consent to inclusion	Children (different utilization) or ≥65 years (Medicare)
Vest, <i>et al.</i> , 2013 ⁸⁷	Commercial query-based web portal product, which includes patients' discharge summaries, prior diagnoses, radiology reports, medication history, and payer information. Both radiology reports and images are accessible within the HIE system and are typically available in near-real time after signoff. Imaging studies are accessible only if the user first views the radiology report. Our analysis is limited to the viewing of reports only.	NR	Patients in health system in western New York	29,528 radiology documents originating at 17 different source organizations, including hospitals and radiology practices. A total of 126 different practice locations viewed these documents.	Claims data only covers 60% of population, included consenting patients with ≥1 encounter in 6 months after consent	<18 years, not in health system (included 60% of pop, not the other 40%), had claims (64%, not the other 36%)

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Vest, <i>et al.</i> , 2012 ⁸⁶	None	Encounter level or retrospective usage	<ul style="list-style-type: none"> -Age -Gender -Race -ED visits over 3 months -Hospitalization over 12 months -Fragmentation (N of clinics -1) -Payer (Medicaid or not) -Charlson comorbidity -Independent mental health/substance abuse comorbidity -AHRQ chronic conditions indicator definitions 	Assessed with multivariate analysis, otherwise NR	Primary care encounter: unit of analysis; multinomial regression, clustered to account of unit of analysis, adjusted for confounders
Vest, <i>et al.</i> , 2013 ⁸⁷	NA	Radiology report access	<ul style="list-style-type: none"> -Demographics -Encounter history -User characteristics -Insurance type -AHRQ CCS ICD-9 codes -Use of services in 30 days prior to access -Claims for imaging procedures -Health professional encounters 	NR	Using network/graph analysis assessed the difference between the average number of connections among sources vs. user practice locations, as well as the average number of radiology documents exchanged by data sources vs. data users. Then (2) mixed effects logistic regression on 134,127 sessions, 64% linked to claims files, with some accounting for clustering by patient, user, workplace - report results without control for confounders, multiple comparisons problem

Author, year	Results
Vest, <i>et al.</i> , 2012 ⁸⁶	<ul style="list-style-type: none"> -Access for 21% of encounters -7,101 encounter based, 1,227 retrospective -Adjusted OR for association with access for female: 1.12; >40 years: 1.16; chronic disease: 1.19; ED visit last 3 months: 1.13; -Retrospective access, same 4 factors plus hospitalized last 4 months OR 1.33 and fragmentation OR 1.52
Vest, <i>et al.</i> , 2013 ⁸⁷	<p>Network: each source organization sent on average 971 (range: 6-8,002) documents to 49 (3-106) other organizations. User organizations accessed on average 49 (1-8,444) documents from 6 (1-17) source organizations. Algorithm suggests 11/17 source organizations represent a core set of data providers, including 8 hospitals and 3 stand-alone radiology sites. Thus the overall number of radiology reports retrieved in the outpatient setting was 16.9 times greater than the number of reports retrieved in the ED and inpatient settings combined (23,201 outpatient vs. 1,333 ED and 313 inpatient).</p> <p>Factors: 86,152 user sessions with associated claims files represented the activity of 1,119 different users representing 145 different workplace locations. 86.4% were staff; physicians represented only about 4% of all sessions; overall 11.2% of sessions included access of radiology reports.</p>

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Vest, <i>et al.</i> , 2014 ⁴⁸	Retrospective cohort	Examines the hypothesis that usage of an HIE system reduces the odds that a patient in the ED will be hospitalized.	Rochester, New York	HEAL NY legislation, statewide HIE initiatives	Claims files from 2 health plans that insure more than 60% of the area population, log files of usage, RHIO roster of users	2009-2010	Rochester RHIO
Vest, <i>et al.</i> , 2014 ⁴⁷	Retrospective cohort	To determine the association between usage of an HIE system post-discharge and 30-day same-cause hospital readmissions.	Rochester, New York	HEAL NY legislation, statewide HIE initiatives. Outpatient	Claims files from 2 health plans that insure more than 60% of the area population, log files of usage, RHIO roster of users	2009-2010	Rochester RHIO

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Vest, <i>et al.</i> , 2014 ⁴⁸	<p>>70 organizations in 13 county regions of western New York.</p> <p>Web-based portal that includes discharge summaries, diagnoses, radiology reports and images, medication history, and payer information</p>	Fully operational in March 2009	1,318 users accessed patient records in 156 different outpatient, emergency, inpatient, long-term care, and specialty care settings via a web portal. 7 EDs were included; 800,000 patients (>70% of the area's adult population)	15645	Claims files for 65% of patients ≥18 years with valid consent dates (n=198,067) who had ≥1 encounter with a provider registered to use the HIE system in the 6 months following their consent date.	None reported
Vest, <i>et al.</i> , 2014 ⁴⁷	Web based portal that includes discharge summaries, diagnoses, radiology reports and images, medication history, and payer information, 38 healthcare organizations in 11 counties	Fully operational in March 2009	800 000 patients (>70% of the area's adult population)	196,314 patients, 11 hospitals (2/3 of sample)	<p>≥18 years, consented during 2009-2010, continuously enrolled in health plan, ≥1 encounter in 6 months following consent, (196,314 patients met these requirements). only the patient's first hospital admission within the first 5 months after consent. Each patient appears in the dataset only once and each discharge could be followed for ≥30 days.</p>	<30 observations in the dataset (n=11)

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Vest, <i>et al.</i> , 2014 ⁴⁸	HIE access vs. no HIE access (from log files)	Hospital admission via the ED Economic	HIE system use at the time of the ED visit, measured in a yes/no fashion	<ul style="list-style-type: none"> -Gender -Age -Payer -Disease severity in the 12-month period -Any primary care, specialty care, or ED visits in the 30 days after the index hospitalization (or up until the date of readmission) 	Logistic regression models. The full model adjusts for all independent variables with patient age, the count of major aggregated diagnostic groups, and the number of prior hospitalizations treated as continuous variables, 4 sensitivity analyses to explore the robustness including physician effects and patient subgroup (sickest) effects
Vest, <i>et al.</i> , 2014 ⁴⁷	HIE access vs. no HIE access (from log files)	Readmission within 30 days of discharge for the same cause as the index hospitalization	HIE system usage	<ul style="list-style-type: none"> -Gender -Age -Payer -Disease severity in the 12-month period any primary care, specialty care, or ED visits in the 30 days after the index hospitalization (or up until the date of readmission) -Described the index hospitalization site: hospital bed size, teaching status, affiliation with a multi-hospital healthcare system, and critical access hospital classification, case mix index derived from the relative values of diagnosis-related groups seen at the hospital. 	Random effects logistic regression models, a series of models adjusting for patient characteristics, then adding post-discharge utilization measures, and lastly including hospital-level characteristics. Controlled for potential hospital-level clustering using the index admission hospital as a random intercept. Then 2 sensitivity analyses.

Author, year	Results
Vest, <i>et al.</i> , 2014 ⁴⁸	<ul style="list-style-type: none"> -ED visit within 6 months of consent: 15,645 -Of ED visits, HIE accessed: 2.4% (n=374) -16/229 MDs used system -OR of admission for Medicare: 2.02; Medicaid: 0.61; male: 1.47 -Adjusted OR of HIE access: 0.7; HIE access on same day as ED visit: 0.83 (95% CI, 0.55 to 1.25) -Odds of an admission were 30% lower when the system was accessed after controlling for confounding (OR 0.70; 95% CI, 0.52 to 0.95) -Annual savings in the sample was \$357,000
Vest, <i>et al.</i> , 2014 ⁴⁷	<ul style="list-style-type: none"> -Readmitted within 30 days: 9.8% (668/6,807); 29.6% at a different facility; 394 had HIE access within 30 days after discharge, 20 (5.8%) readmitted; p=0.00113 -ED visits within 30 days post discharge: NS -HIE access associated with lower readmissions: OR 0.43 (95% CI, 0.27 to 0.70) -Primary care or specialty care associated with lower readmissions rates: ORs 0.48 and 0.67 in final model -ED visits associated with higher rates: OR 9.3 in final model -Accessing patient information in the HIE in the 30 days after discharge associated with a 57% lower adjusted odds of readmission (OR 0.43; 95% CI 0.27 to 0.70). Estimated annual savings in the sample from averted readmissions associated with HIE usage was \$605,000.

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
Willis, <i>et al.</i> , 2013 ⁵⁹	RCT	To evaluate 2 decision support interventions: patient adherence reports to providers and reports to providers and emails to care managers by comparing to usual care.	North Carolina	Out patient	EHR and claims as well as logs of contacts and cost/revenue data	-December 7, 2009-December 6, 2010 was intervention period -Followup for outcomes ended August 30, 2011	Northern Piedmont Community Care Network. Set up a system called COACH (Community-Oriented Approach to Coordinated Healthcare)

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
Willis, <i>et al.</i> , 2013 ⁵⁹	-Included 9 clinics and 5 hospitals -Data collected by the system include: 1) administrative data 2) care management data; 3) claims/billing data ; 4) scheduling data; 5) clinical data; 6) data on communications	NR	Network Medicaid beneficiaries	N=2219 739 to usual care 744 clinic reports 735 clinic reports and care manager notices	Patients with ≥ 1 of 6 targeted IOM priority conditions	Not continuously enrolled during the intervention period

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
Willis, <i>et al.</i> , 2013 ⁵⁹	Provider report vs. provider report and case manager event vs. usual care in which neither type of alert was delivered	<ul style="list-style-type: none"> -Clinical outcomes including: medical adherence, outpatient, ED visits, and hospitalizations -Care coordination costs/revenues -Clinician satisfaction 	Group assignment	None reported	Generalized estimating equation models that accounted for clustering by family

Author, year	Results
Willis, <i>et al.</i> , 2013 ⁵⁹	<p>Control vs. reports vs. reports and email</p> <p>% medication adherence: 41.3% vs. 41.2% vs. 42.9%, p=NS; no differences between groups at 6 months</p> <p>Encounter rates of outpatient: 46.0 vs. 46.6 vs. 44.5, p=NS</p> <p>Encounter rates of ED: 0.87 vs. 0.84 vs. 0.89, p=NS</p> <p>Encounter rates of hospitalizations: 0.19 vs. 0.21 vs. 0.21, p=NS</p> <p>-15% to 50% of reports were not available to providers at time of patient encounter</p> <p>-Even when they had reports, clinicians did not always discuss medication adherence with patients</p>

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
eHealth Initiative 2013 Report ⁶³	Survey on Health Data Exchange administered by the eHealth Initiative	To assess the status of data exchange in the US.	Nationwide	Any	Survey responses	2013; comparison to 2011	Various

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
eHealth Initiative 2013 Report ⁶³	199 of 315 completed the survey; these were a mix of community data exchanges, statewide efforts, & healthcare delivery organizations.	Varies	315 data exchange initiatives were identified	<p>-199 of 315 completed the survey; these were a mix of community data exchanges, statewide efforts, & healthcare (HC) delivery organizations.</p> <p>-90 organizations self-identified as community-based HIEs; 45 as state; 50 as health care delivery organizations.</p> <p>-There is no single dominant model for HIE; 125 organizations used a query model, 124 used secure electronic messaging; 111 used end-to-end integration; 84 used a combination of models.</p> <p>-'Direct' is a standards-based protocol for securely exchanging data; 90 organizations use M117'Direct', mostly in transitions of care.</p> <p>-Patient consent for data exchange generally remains an 'all-or-nothing' proposition, with 'opt-out' the most common consent model.</p>	NR	NR

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
eHealth Initiative 2013 Report ⁶³	NA	<ul style="list-style-type: none"> -Number of initiatives reaching 'advanced stages of operation, sustainability or innovation (as defined by eHI's developmental framework) -Number of years to become operational -Trends in use since 2011 -Number of organizations self-identifying as community, state-, or HC delivery system -Types of professionals most commonly providing and using data -Types of data most commonly provided/viewed -Number having hired personnel from ONC's Workforce Development Program (WDP) -Protocol used for securely exchanging information -Key Findings -Issues for the future 	NR	NR	NR

Author, year	Results
eHealth Initiative 2013 Report ⁶³	<p>84 organizations had reached an 'advanced' stage of operation, sustainability, or innovation. Most took 2 years to become operational.</p> <p>Among organizations responding in 2011 and 2013, 27 more had reached stages 5, 6, or 7 in 2013. 90 organizations self-identified as community-based HIEs; 45 as state-; 50 as HC delivery organizations. Hospitals and Am Care providers are stakeholders most commonly providing/viewing data. Labs also commonly provide data. Community public health clinics commonly view data.</p> <p>24 reported they had hired staff from the ONC's WDP, compared to only 3 in 2011.</p> <p>'Direct' is a standards-based protocol for securely exchanging data; 90 organizations use 'Direct', mostly in transitions of care.</p> <p>There is no single dominant model for HIE; 125 organizations used a query model, 124 used secure electronic messaging; 111 used end-to-end integration; 84 used a combination of models.</p> <p>Key Findings:</p> <ol style="list-style-type: none"> 1) Achieving interoperability with disparate information systems is a major concern; 68 initiatives have had to connect with more than 10 different systems; 2) To overcome interoperability challenges, exchanges would like to see standardized pricing and integration solutions from vendors; 3) Many exchanges are not sharing data with competing organizations; 4) Exchanges are focusing on functionalities to support health reform and advance analytics; 5) Patient engagement remains low amongst organizations exchanging data; 6) Patient consent for data exchange generally remains an 'all-or' nothing' proposition, with 'opt-out' the most common consent model; 7) Since 2011, more initiatives have become more financially viable. However, hospitals and payers are still expected to fund most exchange activity; of the 51 that were NOT sustainable, 31 (of 51) receive more than 50% of their funding from the federal government and 22 report they are a state-HIE. <p>Overall, in 2011, 16 reported they were sustainable; in 2013, 35 reported they were sustainable. Organizations realize the precariousness of government funding and are trying to offer valuable services for a fee.</p> <p>Issues for the future:</p> <ol style="list-style-type: none"> 1) Interoperability concerns need to be addressed; 2) Health reform provides exchanges an opportunity to show value; 3) Patient engagement remains poor.

Author, year	Study Design	Study Purpose/Research Question	Geographic Location	Setting	Data Source(s)/ Evaluation Data	Time Period of Data Collection	Name of HIE (Intervention)
eHealth Initiative 2014 Report ⁶⁴	Survey on Health Data Exchange administered by the eHealth Initiative	To assess the status of data exchange in the US.	Nationwide	Any	Survey responses	2013; comparison to 2011	Various

Author, year	Description of HIE (this will become Types)	Date HIE Implemented	Population	N Sample description (if applicable)	Inclusion Criteria	Exclusion Criteria
eHealth Initiative 2014 Report ⁶⁴	125 of 267 completed the survey; an additional 10 partial responses were included for a total of 135 respondents; 74 community-based HIOs, 25 state-efforts, 26 HC delivery organizations	Varies	267 data exchange initiatives were identified	125 of 267 completed the survey; an additional 10 partial responses were included for a total of 135 respondents; 74 community-based HIOs, 25 state-efforts, 26 HC delivery organizations	NR	NR

Author, year	Comparator or Comparison	Outcomes Measured	Independent Variables	Confounding Variables	Analysis Methods
eHealth Initiative 2014 Report ⁶⁴	NA	<ul style="list-style-type: none"> -Number of organizations that provide data -Number of organizations that use data -Key Barriers -Key Findings -Looking to the future -Stage of maturity 	NR	NR	NR

Author, year	Results
eHealth Initiative 2014 Report ⁶⁴	<p>Who provides data's 112 hospitals, 100 Am Care providers, 56 labs, 52 community/public health clinics.</p> <p>Who accesses data: 111 Am Care providers, 104 hospitals, 75 community/public health clinics, 65 behavioral or mental health providers. Key Barriers: 1) Cost and technical challenges are key barriers to interoperability; 2) Regulatory policies appear to have prompted increased use of core HIE services such as 'Direct', care summary exchange, and transitions of care; 3) Advanced initiatives are supporting new payment and advanced delivery models; 4) Sustainable organizations have replaced federal funding with revenue from fees and membership dues.</p> <p>Key finding 1: Interoperability Challenges include costs of building interfaces, getting consistent and timely response from EMR vendors and interface developers, and technical difficulty of building interfaces. 112 organizations have had to construct multiple interfaces and 18 have had to construct more than 25 interfaces.</p> <p>Suggestions for overcoming interoperability challenges include: 1) standardized pricing and integration solutions from vendors; 2) 'plug and play' platform; 3) federally mandated standards; 4) cultural changes in willingness to share data; 5) greater use among providers of consensus-based standards.</p> <p>Key finding 2: Regulatory Policies prompt use of core HIE Services: 101 incorporate secure messaging into their models; 78 offer a 'Direct' address directory; more respondents are using 'Direct' for all given use cases (when compared to last year). 74 have met at least one Stage 2 Meaningful Use criteria. 7 stages of Development are delineated (see slide in report for detail);</p> <p>Key finding 3: Advanced initiatives are supporting new payment & delivery models: 106 reported they have reached stage 6 (operating) or higher on the eHealth Initiative's HIE maturity scale (an increase of 11% over 2013). 64 support an ACO; 52 support a PCMH; 21 support a State Innovation Model; 12 support a bundled payment initiative.</p> <p>Key finding 4: Sustainable groups replace fed funding with fees and membership dues: 45 use fees to completely cover operational expenses; 38 use fees but need additional funding. 41 report that dues or fees are greatest revenue source; 89 believe dues or fees will eventually be their primary revenue stream.</p> <p>Looking to the future:</p> <ol style="list-style-type: none"> 1) Data exchange is reaching a point of stability and acceptance. 2) Organizations are settling on a set of core service offerings and a standard approach to sustainability (sub-bullet: despite expiration of large funding sources, radical changes in overall landscape are not evident); 3) As organizations mature, they will offer new and innovative services (public health has already leverages HIE; alert notification services may help ACOs to track patients); 4) Organizations are encouraged to work collaboratively to overcome remaining challenges (especially work with regional/community partners to avoid creating 'pockets' of exchange).

* this is from billing data, not EHR

†one site dropped that didn't have comparable qualitative data.

Abbreviations: A1c= glycated hemoglobin; AHA= American Hospital Association; AHRQ= Agency for Healthcare Research and Quality; aka= also known as; AMIE= Arizona medical information exchange; ANOVA= analysis of variance; BHIX= Brooklyn Health Information Exchange; CCD= continuity of care document; CCHIT= Certification Commission for Healthcare Information Technology; CCR= community care record; CCS= clinical classification software; CD4= HIV helper cell count; CDA = clinical document architecture; CDC= Centers for Disease Control and Prevention; CEN= clinical event notification; CHIC RHIO= Carolina HIV information cooperative regional health information organization; CI= confidence interval; CIO= chief information officer; COACH= Community Oriented Approach to Coordinated Healthcare; CPT4= Current procedure Terminology; CT= computed axial tomography scan; DOD= Department of Defense; e= electronic; e.g.= for example; ebSML RIM= electronic business using extensible markup language registry information model; ebXML RS= electronic business using extensible markup language; ED= emergency department; EDIFACT= electronic data interchange for administration, commerce and transport; eHIE= electronic health information exchange; EHR= electronic health records; EKG= electrocardiogram; ELRs = enhanced laboratory reports; EMR= electronic medical records; EMS= emergency medical services; EPIC= electronic privacy information center; et al.= and others; etc.= etcetera; FITT= fit between individuals tasks and technologies; FUHN= Federally Qualified Health Center Urban Health network; FQHCs= federally qualified health centers; GDP= gross domestic product; GP= general practitioner; HC= Health Care; HCAHPS= Hospital Consumer Assessment of Healthcare Providers and Systems; HEAL = Health Care Efficiency and Affordability Law; HEAL NY= Health Care Efficiency and Affordability Law for New York; HEDIS= health care effectiveness data and information set; HIE= health information exchange; HIMSS= healthcare information and management systems society; HIMSS-AD= healthcare information and management systems society analytical database; HIO= Health Insuring Organization; HIPAA= Health Insurance Portability and Accountability Act; HITECH= Health Information Technology for Economic & Clinical Health Act; HL-7= Health Level 7; HL7; HMO= health maintenance organization; HRR= unadjusted hazard ratio; HRSA= `Health Resources and Services Administration; Id = Identifier; i.e.= that is; ICC= integrated care collaboration; ICD-9= Ninth Revision of the International Classification of Diseases; ICD-9-CM= International Classifications of Diseases, Clinical Modification; ICU= intensive care unit; IDS= integrated delivery system; I-EMS= Indianapolis Emergency Medical Services; IHIE= Indiana Health Information Exchange; INPC= Indiana Network fro Patient Care; IOM= Institute of Medicine's; IQR= interquartile range; IS = information system; IT= information technology; KP= Kaiser Permanente?; LaPHIE= Louisiana Public Health Information Exchange; LBNH= Long Beach Network for Health; LOINC= Logical Observation Identifiers Names and Codes; MAeHC= Massachusetts eHealth Collaborative; MANOVA= multivariate analysis of variance; MD= Doctor of Medicine; MEGAHIT= Medical Evidence Gathering Through Health IT; MHDC= Massachusetts Health Data Consortium; mL= milliliter; mm= millimeter; MN= Minnesota; MPI= master patient index; MRI= magnetic resonance imaging; MRSA= Methicillin Resistant Staphylococcus Aureus; MSeHA= MidSouth e-Health Alliance; N= sample size; NA= not applicable; NAMCS= National Ambulatory Medical Care Survey; NDC= National Drug Code; NE= northeast; NHIN= Nationwide Health Information Network; NLM= National Library of Medicine; NR= not relevant; NS= not significant; NY= New York; NYCLIX= New York Clinical Information Exchange; OLS= ordinary least squares; ONC= Office of the National Coordinator for Health Information Technology; OR= odds ratio; PBMs= pharmacy benefit managers; PC= primary care; PCP = primary care provider; PDF= portable document format; PHI= personal health information; PHR= personal health record; PPO= preferred provider organization; QUIS= Questionnaire for User Interaction Satisfaction; RCT= randomized, controlled trial; RHIO= regional health information organization; RLS= record locator service; RNA= ribonucleic acid; RR= relative risk; SD= standard deviation; S.E.= southeast; SF-12= Short Form-12 item survey; SHIN-NY= Statewide Health Information Network for New York; SMRTnet= Secure Medical Records Transfer Network; SNOCAP-USA= State Networks of Colorado Ambulatory Practices & Partners United States of America; SNOMED= Systemized Nomenclature of Medicine; SSA= Social Security Administration; SUNBH = Seoul National University Bundang Hospital; TILAK= Tiroler Landeskrankenanstalten ; TOE= technological, organizational and environmental; TUMA= Trans-mural exchange of medication data in Almere; U.K.= United Kingdom; U.S.= United States; URL= uniform resource locator; USB= universal serial bus; VA= U.S. Department of Veterans Affairs; VL= viral load; VLER= Veterans Lifetime Electronic Record; VRE= Vancomycin resistant enterococci; vs.= versus; WHIE= Wisconsin Health Information Exchange; XML= extensible markup language.

Appendix H. Quality Assessment Tables

Table H1. Quality Assessment of Randomized Controlled Trials

Author, Year	Randomization adequate?	Allocation concealment adequate?	Groups similar at baseline?	Maintain Comparable Groups?	Eligibility criteria specified?	Outcome assessors masked?	Care provider masked?	Patient masked?
Afilalo, <i>et al.</i> , 2007 ⁵⁸ Lang, <i>et al.</i> , 2006 ⁵⁷	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Willis, <i>et al.</i> , 2013 ⁶²	Yes	Not Reported	Unclear	Unclear	Yes	Yes	No	Unclear

Author, Year	Reporting of attrition, crossovers, adherence, and contamination	No Loss to followup: differential/high	Intention-to-treat analysis	No Post-randomization exclusions	Outcomes Prespecified	Funding source	Risk of bias
Afilalo, <i>et al.</i> , 2007 ⁵⁸ Lang, <i>et al.</i> , 2006 ⁵⁷	Unclear	No	No	No	Yes	Yes	Moderate
Willis, <i>et al.</i> , 2013 ⁶²	Yes	Yes	Yes	Yes	Yes	Agency for Healthcare Research and Quality	Moderate

Table H2. Quality Assessment of Cohort Studie

Author, year	Study Design	Are the comparison groups or time periods appropriate?	Were the inclusion and exclusion criteria specified and applied equally to each group?	Did the design and analyses account for important potential confounding and modifying variables appropriately?	Were valid and reliable measures used? (inclusion/exclusion, confounding, outcomes)	Were non-biased and valid ascertainment methods used? (inclusion/exclusion, confounding, outcomes)
Bailey, <i>et al.</i> , 2013 ³²	Retrospective cohort	Yes	Yes	Yes	Yes	NR
Bailey, <i>et al.</i> , 2012 ³¹	Retrospective cohort	Yes	Yes	Yes	Yes	NR
Ben-Assuli, Shabtai and Leshno, 2013 ³³	Retrospective cohort	Yes/No-(HIE vs. EMR+no EMR)	NR	Yes	NR	NR
Dixon, McGowan and Grannis, 2011 ³⁴	Retrospective analysis	Yes	NA	NA	Yes	NA
Frisse <i>et al.</i> , 2012 ³⁶	Retrospective cohort	Yes	Yes	Yes	Yes	Yes
Jones, Friedberg and Schneider, 2011 ⁶⁰	Retrospective, cross-sectional analysis	Yes	Yes	Yes	Yes	Yes
Kern <i>et al.</i> , 2012 ³⁷	Retrospective cohort	Yes	Yes	Yes	Yes	NR
Kho <i>et al.</i> , 2013 ⁷⁷	Descriptive	NA	Yes	No	Yes	Yes
Lammers, Adler-Milstein and Kocher, 2014 ⁶¹	Retrospective cohort	Yes	Yes	Yes	Yes	Yes
Lobach, <i>et al.</i> , 2007 ⁸⁵	Descriptive	NA	NA	NA	Yes	NA
Maass, <i>et al.</i> , 2008 ⁵³	Workflow study	No	No	No	No	No
Magnus, <i>et al.</i> , 2012 ³⁹	Prospective case-cohort	Yes	Yes	Yes	Yes	NR
Maenpaa <i>et al.</i> , 2011 ³⁸	Retrospective analysis of utilization	Yes	Yes	Yes	Yes	Yes

Author, year	Was the timing and/or time period for the measurement of the intervention and outcomes appropriate?	Was there no missing data? If missing data, was it handled appropriately?	Were outcomes prespecified and were prespecified outcomes reported?	Risk of bias
Bailey, <i>et al.</i> , 2013 ³²	Yes	Yes	Yes	Moderate
Bailey, <i>et al.</i> , 2012 ³¹	Yes	NR	Yes	Moderate
Ben-Assuli, Shabtai and Leshno, 2013 ³³	Yes	Yes	Yes	Moderate
Dixon, McGowan and Grannis, 2011 ³⁴	NA	Unknown	Yes	Moderate
Frisse <i>et al.</i> , 2012 ³⁶	Yes	Yes	Yes	Moderate
Jones, Friedberg and Schneider, 2011 ⁶⁰	Yes	NR	Yes	Moderate
Kern <i>et al.</i> , 2012 ³⁷	Yes	No	Yes	Moderate
Kho <i>et al.</i> , 2013 ⁷⁷	Yes	Yes	NA	Low
Lammers, Adler-Milstein and Kocher, 2014 ⁶¹	Yes	Yes	Yes	Moderate
Lobach, <i>et al.</i> , 2007 ⁸⁵	Yes	Unclear	NA	Low
Maass, <i>et al.</i> , 2008 ⁵³	NA	NA	No	High
Magnus, <i>et al.</i> , 2012 ³⁹	Yes	NR	Yes	Low
Maenpaa <i>et al.</i> , 2011 ³⁸	Yes	No	Yes	Moderate

Author, year	Study Design	Are the comparison groups or time periods appropriate?	Were the inclusion and exclusion criteria specified and applied equally to each group?	Did the design and analyses account for important potential confounding and modifying variables appropriately?	Were valid and reliable measures used? (inclusion/exclusion, confounding, outcomes)	Were non-biased and valid ascertainment methods used? (inclusion/exclusion, confounding, outcomes)
McCarthy <i>et al.</i> , 2014 ¹²²	Case studies and cross case analysis	Unclear	Yes	No	No	No
McGowan <i>et al.</i> , 2007 ¹³²	Case study	No	No	No	NO	No
Miller and Tucker, 2014 ¹⁴⁵	Cross-sectional	Yes	Yes	No	Yes	No
Moore, <i>et al.</i> , 2012 ⁹¹	Retrospective cohort	No comparison group	Yes	No	Yes	No
Nagykaldi, <i>et al.</i> , 2014 ⁵⁴⁰	Pre-post	Yes	NR	No: descriptive only.	NR	NR
Onyile, <i>et al.</i> , 2013 ¹⁰⁸	Geographic analysis	Yes	Yes	NA	Yes	Yes
Park, <i>et al.</i> , 2013 ⁵³	Pre- post- HIE implementation survey	Yes	Yes	Unclear	Yes	Yes
Ross <i>et al.</i> , 2013 ⁴²	Retrospective Cohort	Unclear	Yes	Yes	Yes	Unclear
Saff, <i>et al.</i> , 2010 ¹³⁵	Case study	NA	NA	No	Uncertain	Unclear
Shapiro, <i>et al.</i> , 2013 ⁴³	Retrospective analysis of clinical data	Yes	Yes	Yes	Yes	Yes
Silvester and Carr, 2009 ⁹⁹	Quasi-experiment (pre-/post)	Yes	Yes	No	Yes	Yes
Tzeel, Lawnicki and Pemble, 2012 ⁴⁵	Retrospective cohort	Yes	Yes	Yes	Yes	Unclear

Author, year	Was the timing and/or time period for the measurement of the intervention and outcomes appropriate?	Was there no missing data? If missing data, was it handled appropriately?	Were outcomes prespecified and were prespecified outcomes reported?	Risk of bias
McCarthy <i>et al.</i> , 2014 ¹²²	Yes	NA	No	Moderate
McGowan <i>et al.</i> , 2007 ¹³²	No	Unclear	No	High
Miller and Tucker, 2014 ¹⁴⁵	Yes	Potentially missing data handled to best of their ability	Yes	Moderate
Moore, <i>et al.</i> , 2012 ⁹¹	Yes	Yes	Yes	Moderate
Nagykaldi, <i>et al.</i> , 2014 ⁵⁴⁰	Yes	NR	Yes	Moderate
Onyile, <i>et al.</i> , 2013 ¹⁰⁸	Yes	Not clear	NA	Low
Park, <i>et al.</i> , 2013 ⁵³	Yes	96% response rates	Yes	Moderate
Ross <i>et al.</i> , 2013 ⁴²	Yes	Unclear	Yes	Moderate
Saff, <i>et al.</i> , 2010 ¹³⁵	Yes	Unclear	No	High
Shapiro, <i>et al.</i> , 2013 ⁴³	Yes	Yes	Yes	Moderate
Silvester and Carr, 2009 ⁹⁹	Yes	Yes	Yes	High
Tzeel, Lawnicki and Pemble, 2012 ⁴⁵	Yes	Yes	Yes	Moderate

Author, year	Study Design	Are the comparison groups or time periods appropriate?	Were the inclusion and exclusion criteria specified and applied equally to each group?	Did the design and analyses account for important potential confounding and modifying variables appropriately?	Were valid and reliable measures used? (inclusion/exclusion, confounding, outcomes)	Were non-biased and valid ascertainment methods used? (inclusion/exclusion, confounding, outcomes)
Tzeel, Lawnicki and Pemble, 2011 ⁴⁴	Retrospective cohort	Yes	Yes	Yes	Yes	Unclear
Vest, 2009 ⁴⁶	Retrospective cohort	Yes	Yes	Yes	Yes	Yes
Vest, 2010 ¹⁴⁶	Case control (defines groups by outcome: HIE	Yes	Yes	Yes	Yes	Yes
Vest, <i>et al.</i> , 2011 ⁸⁹	Case control (defines groups by outcome: HIE	Yes	Yes	Yes	Yes	Yes
Vest, <i>et al.</i> , 2011 ⁹⁰	Case control (defines groups by outcome: HIE participation)	Yes	Yes	Yes	Yes	Yes
Vest and Miller, 2011 ⁵⁶	Cross sectional (logistic regression)	Yes	Yes	Yes	Yes (no information on survey reporting)	Yes (Data are from multiple surveys)
Vest, <i>et al.</i> , 2012 ⁸⁶	Case control	Yes	Yes	Yes	Yes	Yes
Vest and Jaspersen, 2012 ⁸⁸	Retrospective audit log	No comparison group; time period appropriate	Yes	Yes	Yes	Yes
Vest, <i>et al.</i> , 2013 ⁸⁷	Case control (defines groups by outcome: HIE	Unclear	Yes	No	Yes	No
Vest, <i>et al.</i> , 2014 ⁴⁷	Retrospective cohort	Yes	Yes	Unclear	Yes	Yes
Vest, <i>et al.</i> , 2014 ⁴⁸	Retrospective cohort	Yes	Yes	No	Yes	Yes

Author, year	Was the timing and/or time period for the measurement of the intervention and outcomes appropriate?	Was there no missing data? If missing data, was it handled appropriately?	Were outcomes prespecified and were prespecified outcomes reported?	Risk of bias
Tzeel, Lawnicki and Pemble, 2011 ⁴⁴	Yes	Yes	Yes	Moderate
Vest, 2009 ⁴⁶	Yes	Yes	Yes	Moderate
Vest, 2010 ¹⁴⁶	Yes	Yes	Yes	Low
Vest, <i>et al.</i> , 2011 ⁸⁹	Yes	Not clear	Yes	Low
Vest, <i>et al.</i> , 2011 ⁹⁰	Yes	Not clear	Yes	Low
Vest and Miller, 2011 ⁵⁶	Yes	No, Yes	Yes	Low
Vest, <i>et al.</i> , 2012 ⁸⁶	Yes	Unclear	Yes	Low
Vest and Jaspersen, 2012 ⁸⁸	Yes	Yes	Yes	Low
Vest, <i>et al.</i> , 2013 ⁸⁷	No	Not clear	Yes	Moderate
Vest, <i>et al.</i> , 2014 ⁴⁷	Yes	Not clear	Yes	Moderate
Vest, <i>et al.</i> , 2014 ⁴⁸	Yes	Not clear	Yes	Moderate

Abbreviations: EMR= electronic medical record; HIE = health information exchange; NA = not applicable; NR =not reported.

Table H3. Quality Assessment of Surveys, Focus Groups, and Interview Studies

Author, year	1. Is the sampling strategy or selection criteria reported and appropriate?	2. Are the response or participation rates reported and are they acceptable given the type of study?	3. Are characteristics (e.g., demographics) of respondents/participants reported?	4. Is how the questions were developed/selected reported and is it appropriate?
Abramson, <i>et al.</i> , 2012 ⁶⁵	Yes	Yes, 72%	Yes, hospitals in New York State	Yes
Abramson, <i>et al.</i> , 2014 ⁶⁶	Yes	59.3% (375/632) response rate	Yes, nursing homes in New York State	Yes
Adler-Milstein, <i>et al.</i> , 2008 ⁷⁰	Yes	Yes, 60%		Yes
Adler-Milstein, Bates and Jha, 2009 ⁶⁷	Yes	Yes, 78%	Yes, operational RHIOs	Yes, pilot testing
Adler-Milstein, Landefeld and Jha, 2010 ⁶⁹	Yes	Yes, 83%	Yes, operational RHIOs	Yes
Adler-Milstein, Bates and Jha, 2011 ⁶⁸	Yes	Yes, 84%	Yes, operational RHIOs	Yes
Adler-Milstein, DesRoches and Jha, 2011 ⁹²	Yes	Yes - 69%	Yes	Yes
Adler-Milstein, Bates and Jha, 2013 ²²	Yes	Yes, 78%	Yes, operational RHIOs	Yes, pilot testing
Adler-Milstein and Jha, 2014 ⁹³	Yes	Yes	Yes	Yes
Altman, <i>et al.</i> , 2012 ⁴⁹	Unclear; convenience sample	Yes, 70% (14/20)	Yes	Yes
Audet, Squires and Doty, 2014 ⁹⁴	Yes	Yes, 35%	Yes	Yes
Campion, <i>et al.</i> , 2012 ⁵⁰	Yes	Yes (19%)	Yes	Yes
Carr, <i>et al.</i> , 2014 ⁶²	Yes	Yes, but only 13.8%	Not well, but were clinician users of HIE system	Yes, but inappropriate detail provided

Author, year	5. Were confounders considered? (could be in analysis or presentation, such as stratifying results)	6. Is analysis appropriate? (given the type of data)	Risk of bias
Abramson, <i>et al.</i> , 2012 ⁶⁵	Unclear	Yes	Low
Abramson, <i>et al.</i> , 2014 ⁶⁶	Unclear	Yes	Low
Adler-Milstein, <i>et al.</i> , 2008 ⁷⁰	Unclear	Yes	Low
Adler-Milstein, Bates and Jha, 2009 ⁶⁷	Unclear	Yes	Low
Adler-Milstein, Landefeld and Jha, 2010 ⁶⁹	Unclear	Yes	Low
Adler-Milstein, Bates and Jha, 2011 ⁶⁸	Unclear	Yes	Low
Adler-Milstein, DesRoches and Jha, 2011 ⁹²	Yes	Yes	Low
Adler-Milstein, Bates and Jha, 2013 ²²	Unclear	Yes	Low
Adler-Milstein and Jha, 2014 ⁹³	Unclear	Yes	Low
Altman, <i>et al.</i> , 2012 ⁴⁹	NA, descriptive interviews	Mostly descriptive results presented	Moderate
Audet, Squires and Doty, 2014 ⁹⁴	Unclear	Yes	Low risk of bias
Campion, <i>et al.</i> , 2012 ⁵⁰	Yes	Yes	Moderate
Carr, <i>et al.</i> , 2014 ⁶²	Unclear	Yes	High

Author, year	1. Is the sampling strategy or selection criteria reported and appropriate?	2. Are the response or participation rates reported and are they acceptable given the type of study?	3. Are characteristics (e.g., demographics) of respondents/participants reported?	4. Is how the questions were developed/selected reported and is it appropriate?
Chang, <i>et al.</i> , 2010 ⁵⁰	No	No, 9 primary care physicians selected for convenience	"Primary care physicians"	Yes, but inappropriate detail provided
Dixon, Miller and Overhage, 2013 ¹³⁹	Yes	Yes	Yes	Yes
Dixon, Jones and Grannis, 2013 ⁷²	Yes	Yes, 69% (44/63)	"Infection preventionists"	Yes, pilot administration with modification of survey
Fairbrother, <i>et al.</i> , 2014 ¹¹⁹	Yes	NR but these were interviews	Yes	NR
Foldy, 2007 ⁷³	Unclear-basically asked experts whom to ask	Yes	No	NR
Fontaine, <i>et al.</i> , 2010 ⁷⁴	Yes	NR	NR	Yes
Furukawa, 2014 ⁹⁵	Yes	Yes	Yes	Unclear
Furukawa, 2013 ⁹⁶	Yes	Yes	No	Yes
Gadd, <i>et al.</i> , 2011 ⁷⁵	Yes	Yes, email survey responses from with 70% response rate from health care professionals (165/237).	Yes	Yes
Genes, <i>et al.</i> , 2011 ¹²⁰	Yes	Yes, 18/22 participated in interviews	Yes	Yes, Yes
Goldwater, <i>et al.</i> , 2014 ¹³¹	Yes	Yes for interviews. 20% response to emailed survey.	No	NR
Hamann and Bezboruah, 2013 ⁹⁸	Yes	Yes	NA	Yes
Hessler, <i>et al.</i> , 2009 ⁷⁶	Yes	No	Yes	Yes

Author, year	5. Were confounders considered? (could be in analysis or presentation, such as stratifying results)	6. Is analysis appropriate? (given the type of data)	Risk of bias
Chang, <i>et al.</i> , 2010 ⁵⁰	Unclear	No	Moderate
Dixon, Miller and Overhage, 2013 ¹³⁹	No	Yes	Moderate
Dixon, Jones and Grannis, 2013 ⁷²	Unclear	Yes	Moderate
Fairbrother, <i>et al.</i> , 2014 ¹¹⁹	NA	NR	High
Foldy, 2007 ⁷³	No	Yes	Moderate
Fontaine, <i>et al.</i> , 2010 ⁷⁴	No	Yes	Moderate
Furukawa, 2014 ⁹⁵	Yes	Yes	Low
Furukawa, 2013 ⁹⁶	Yes	Yes	Low
Gadd, <i>et al.</i> , 2011 ⁷⁵	Yes	Yes	Low
Genes, <i>et al.</i> , 2011 ¹²⁰	NA	Yes	Low
Goldwater, <i>et al.</i> , 2014 ¹³¹	NA	Yes, descriptive only	Moderate
Hamann and Bezboruah, 2013 ⁹⁸	Yes	Yes	Low
Hessler, <i>et al.</i> , 2009 ⁷⁶	No	No	High

Author, year	1. Is the sampling strategy or selection criteria reported and appropriate?	2. Are the response or participation rates reported and are they acceptable given the type of study?	3. Are characteristics (e.g., demographics) of respondents/participants reported?	4. Is how the questions were developed/selected reported and is it appropriate?
Hincapie, <i>et al.</i> , 2011 ¹⁰⁹	Yes	NR	No, no table of participants. Types of providers were mentioned with qualitative themes.	Yes
Jha, <i>et al.</i> , 2008 ¹⁰²	Yes	No	No	No
Jones, Friedberg and Schneider, 2011 ⁶⁰	Yes for retrospective cross-sectional	Yes, Yes (58%)	Yes	NR but referenced the American Hospital Association survey
Kaushal, <i>et al.</i> , 2010 ⁵²	No	Yes	No	Yes
Kern, <i>et al.</i> , 2009 ¹⁴⁰	Yes	Yes	Yes	Yes
Kern, <i>et al.</i> , 2011 ¹⁴⁴	No	Yes	No	Yes
Kierkegaard, Kaushal and Vest, 2014 ¹¹⁰	Yes	NA	Yes, characteristics of sites reported and types of HIE users are described but not quantified.	NR
Lee, <i>et al.</i> , 2012 ⁷⁸	Unclear (post given to all, for pre this is unclear)	No (rate given but low; only collected for 2 weeks)	Yes	Yes
Machan, Ammenwerth and Schabetsberger, 2006 ⁵⁴	Yes, questionnaire sent to all practioners registered in HIE project.	Yes, 43% (104/242) practitioners responded.	Yes, physician users of HIE.	Yes, development process for interviews guide and questionnaire described thoroughly. No psychometrics presented.
Massy-Westropp, <i>et al.</i> , 2005 ¹¹¹	Yes, convenience sample of 82 users of HIE and then additional sample of 50 providers not in HIE program as controls.	Reported as 42% (55/80) but this doesn't account for 50 controls so the response rate is 24% (55/132).	No	No

Author, year	5. Were confounders considered? (could be in analysis or presentation, such as stratifying results)	6. Is analysis appropriate? (given the type of data)	Risk of bias
Hincapie, <i>et al.</i> , 2011 ¹⁰⁹	NA	Yes	Moderate
Jha, <i>et al.</i> , 2008 ¹⁰²	No	Unclear	High
Jones, Friedberg and Schneider, 2011 ⁶⁰	Yes	Yes	Low
Kaushal, <i>et al.</i> , 2010 ⁵²	No	Yes	High
Kern, <i>et al.</i> , 2009 ¹⁴⁰	No	Yes	Moderate
Kern, <i>et al.</i> , 2011 ¹⁴⁴	No	No	High
Kierkegaard, Kaushal and Vest, 2014 ¹¹⁰	NA	Yes, coded interviews	Moderate
Lee, <i>et al.</i> , 2012 ⁷⁸	Yes	No	High
Machan, Ammenwerth and Schabetsberger, 2006 ⁵⁴	No, only descriptive analysis	Yes, descriptive analysis only.	Low
Massy-Westropp, <i>et al.</i> , 2005 ¹¹¹	No	NA	High

Author, year	1. Is the sampling strategy or selection criteria reported and appropriate?	2. Are the response or participation rates reported and are they acceptable given the type of study?	3. Are characteristics (e.g., demographics) of respondents/participants reported?	4. Is how the questions were developed/selected reported and is it appropriate?
McCullough, <i>et al.</i> , 2014 ¹¹²	Yes, used purposive sample strategy	Yes, reported recruitment rate of practices.	Yes	Yes
Merrill, <i>et al.</i> , 2013 ¹³⁷	Yes	Yes	Yes	Yes
Messer, <i>et al.</i> , 2012 ¹¹³	Yes, interviews and assessment with 39 stakeholders; pre and post survey of 29 providers' satisfaction with HIE, relationships with other providers, barriers.	NR, it is not clear how many surveys were sent out to compute a response rate.	No	Yes
Miller, 2012 ¹²³	Qualitative	Yes	NR, but these were interviews	NR
Myers, <i>et al.</i> , 2012 ¹¹⁷	Yes, used purposive sample strategy	Yes, 62/102 emailed invitations to survey	Yes for key respondents. No for survey.	Yes, developed after literature review. Reported Chronbach alphas of .57-.97 for scaled items.
Nykänen and Karimaa, 2006 ¹⁴²	Yes	Yes	No	Yes
Ozkaynak and Brennan, 2013 ¹¹⁴	Yes	NA	Yes	NR
Patel, <i>et al.</i> , 2013 ⁸⁰	Yes	Yes	Yes	yes
Phillips, <i>et al.</i> , 2014 ¹³³	Yes	NA	No	Yes

Author, year	5. Were confounders considered? (could be in analysis or presentation, such as stratifying results)	6. Is analysis appropriate? (given the type of data)	Risk of bias
McCullough, <i>et al.</i> , 2014 ¹¹²	NA	Yes	Low
Merrill, <i>et al.</i> , 2013 ¹³⁷	Yes	Yes	Low
Messer, <i>et al.</i> , 2012 ¹¹³	NA	Yes, for qualitative and quantitative.	Low
Miller, 2012 ¹²³	Yes, questions developed jointly by the University of California, San Francisco, and Consumers Union	NA	Yes
Myers, <i>et al.</i> , 2012 ¹¹⁷	Stratified by role	Yes	Low
Nykänen and Karimaa, 2006 ¹⁴²	No	Yes	Moderate
Ozkaynak and Brennan, 2013 ¹¹⁴	NA	Yes	Moderate
Patel, <i>et al.</i> , 2013 ⁸⁰	Yes	Yes	Low
Phillips, <i>et al.</i> , 2014 ¹³³	Yes	Yes	Low

Author, year	1. Is the sampling strategy or selection criteria reported and appropriate?	2. Are the response or participation rates reported and are they acceptable given the type of study?	3. Are characteristics (e.g., demographics) of respondents/participants reported?	4. Is how the questions were developed/selected reported and is it appropriate?
Pirnejad, Bal and Berg, 2008 ¹³⁴	Yes for RN surveys; No for interviews	Yes	Yes	Yes for surveys - published surveys used to identify questions; No for interviews
Ross, <i>et al.</i> , 2010 ¹²⁵	Yes	Yes	No	Yes
Rudin, <i>et al.</i> , 2009 ¹²⁶	Yes	Not reported	No	Yes
Rudin, <i>et al.</i> , 2011 ¹¹⁵	Yes	NR	Yes	Yes
Sciotte and Paré, 2010 ¹²⁷	Yes	Yes	NR	Yes
Steward, <i>et al.</i> , 2012 ¹²⁸	Yes	NR but these were interviews	NR	Partnered with UCSF qualitative experts to conduct the interviews.
Soderberg and Laventure, 2013 ⁷⁹	Yes	Yes	No	Unclear
Thorn, Carter and Bailey, 2014 ¹¹⁶	Yes, used purposive sample strategy	Yes, mentioned all physicians agreed to participate and no one dropped out.	Yes	Types of questions mentioned but no mention of interview guide.
Unertl, <i>et al.</i> , 2013 ¹³⁶	Yes	Yes	NR	Yes

Author, year	5. Were confounders considered? (could be in analysis or presentation, such as stratifying results)	6. Is analysis appropriate? (given the type of data)	Risk of bias
Pirnejad, Bal and Berg, 2008 ¹³⁴	No	Yes	Moderate
Ross, <i>et al.</i> , 2010 ¹²⁵	No	Yes	Moderate
Rudin, <i>et al.</i> , 2009 ¹²⁶	No	Yes	Moderate
Rudin, <i>et al.</i> , 2011 ¹¹⁵	NA	Yes	Low
Sciotte and Paré, 2010 ¹²⁷	Yes	Yes	Low
Steward, <i>et al.</i> , 2012 ¹²⁸	NA.	Yes	Moderate
Soderberg and Laventure, 2013 ⁷⁹	Yes	Yes	Moderate
Thorn, Carter and Bailey, 2014 ¹¹⁶	NA	Yes	Low
Unertl, <i>et al.</i> , 2013 ¹³⁶	Yes	Yes	Low

Abbreviations: HIE = health information exchange; NA = not applicable; NR = not reported; RHIO = regional health information organization; RN = registered nurse; UCSF = University of California, San Francisco.