

Usage and Effect of Health Information Exchange

A Systematic Review

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Background: Health information exchange (HIE) is increasing in the United States, and it is incentivized by government policies.

Purpose: To systematically review and evaluate evidence of the use and effect of HIE on clinical care.

Data Sources: Selected databases from 1 January 2003 to 31 May 2014.

Study Selection: English-language hypothesis-testing or quantitative studies of several types of data exchange among unaffiliated organizations for use in clinical care that addressed health outcomes, efficiency, utilization, costs, satisfaction, HIE usage, sustainability, and attitudes or barriers.

Data Extraction: Data extraction was done in duplicate.

Data Synthesis: Low-quality evidence from 12 hypothesis-testing studies supports an effect of HIE use on reduced use or costs in the emergency department. Direct evidence that HIEs were used by providers was reported in 21 studies involving 13 distinct HIE organizations, 6 of which were located in New York, and generally showed usage in less than 10% of patient encounters. Findings

from 17 studies of sustainability suggest that approximately one quarter of existing HIE organizations consider themselves financially stable. Findings from 38 studies about attitudes and barriers showed that providers, patients, and other stakeholders consider HIE to be valuable, but barriers include technical and workflow issues, costs, and privacy concerns.

Limitation: Publication bias, possible selective reporting of outcomes, and a dearth of reporting on context and implementation processes.

Conclusion: Health information exchange use probably reduces emergency department usage and costs in some cases. Effects on other outcomes are unknown. All stakeholders claim to value HIE, but many barriers to acceptance and sustainability exist. A small portion of operational HIEs have been evaluated, and more research is needed to identify and understand success factors.

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Health care providers are increasingly sharing clinical data with other providers who care for the same patient by using electronic health information exchange (HIE). In the United States, more than 100 organizations facilitate HIEs among provider organizations, and 30% of hospitals and 10% of ambulatory clinics participate (1). This development has been driven by the belief that information exchange will address the current fragmentation of patient care across providers, thereby improving care, enhancing patient satisfaction, and making care more efficient by reducing the use of redundant health care services (2, 3).

Use of HIE is also spurred by financial incentives created by the Health Information Technology for Economic and Clinical Health Act of 2009 and outlined in the Centers for Medicare & Medicaid Services meaningful use rules. Stage 2 meaningful use objectives include exchanging clinical data with other providers and may be expanded in stage 3. Nearly \$600 million in federal funding was designated to support statewide HIE organizations. Some states have invested substantial additional funding (4). Although policy already creates incentives for providers and hospitals to achieve these objectives, little is known about how HIE capabilities are used in clinical care and their observed effects. This information could inform better design and implementation of HIE programs to improve patient outcomes and achieve efficiencies.

We conducted a systematic review to evaluate the HIE literature, specifically investigating the evidence of effect on

health outcomes, health care utilization and efficiency, evidence of clinicians' usage of HIE, and financial sustainability of HIE organizations. We also evaluated evidence about patient and providers attitudes toward HIE as well as barriers or facilitators to HIE use.

METHODS

This systematic review is reported according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (5). A formal protocol was developed and submitted to PROSPERO, which included the key questions, search strategy, and inclusion and exclusion criteria (CRD42014007469). A technical expert panel provided input on the protocol and preliminary results.

Data Sources and Searches

We conducted a review of key terms related to HIE from PubMed, Web of Science, the Cochrane Databases, and gray literature from 1 January 2003 to 31 May 2014 (Supplement 1, available at www.annals.org). We obtained additional references from key articles ("reference mining")

See also:

**Web-Only
Supplements**

Key Summary Points

Relatively few of the more than 100 operational U.S. health information exchanges (HIEs) have been the subject of published evaluations.

Of the HIEs that have been evaluated, low-quality evidence from 12 hypothesis-testing studies supports an effect of HIE use on reduced utilization or costs in the emergency department. The effects of HIE on other health care outcomes are uncertain.

The use of HIE is low relative to the estimated potential need; most studies reported use in 2% to 10% of encounters. However, some sites have reported much greater HIE use, and specifics of the context and implementation may be responsible for these differences.

All stakeholders claim to value HIE, but many barriers to acceptance and sustainability exist, including workflow and interface issues, privacy and security of patient health information, and the lack of a compelling business case for sustainability.

and content experts, and we used results from previous health information technology (IT) literature reviews conducted between 1 January 1990 and 13 August 2013, which included HIE (6–9). Because approaches to HIE are embedded within the idiosyncrasies of health systems and our focus was the U.S. health care system, we limited the search to articles published in English and within the U.S. context.

Study Selection

We focused on the potential to exchange several types of clinical information on specific patients across institutions in different health systems, which is consistent with the definition described in the U.S. national HIE strategy and with the definition of a “basic” HIE according to Adler-Milstein and colleagues (10). We excluded administration and financial information exchange; studies that involved the transmission of data for public health, such as those on reportable diseases; single-focus data, such as those about antimicrobial resistance or HIV laboratory tests; data exchange across facilities but within systems, such as across Veterans Affairs or Kaiser Permanente facilities; and 1 study about exchange of data between the U.S. Department of Defense and Veterans Affairs because of limited generalizability.

Articles were eligible if they met this definition of HIE and if the study design was “descriptive, qualitative”; “descriptive, quantitative”; or “hypothesis-testing” (including randomized controlled trials) following classifications first used by Chaudhry and colleagues [8]. Articles were also eligible if they were systematic reviews. Descriptive, qualitative studies that provided only a description of an HIE

were not included, but those that used qualitative methods to evaluate barriers or facilitators were included. Descriptive, quantitative or hypothesis-testing papers were included if they focused on clinical or health outcomes, efficiency, health care utilization, patient or provider satisfaction, attitudes, HIE usage, and financial sustainability of HIE organizations (11). We excluded a class of papers we called “case studies,” which were narrative descriptions about particular HIEs (which included their history, architecture, and challenges) but were distinguished from included studies in that they did not include Methods sections or a priori study questions about outcomes, use, costs, sustainability, or attitudes or barriers.

Data Extraction and Quality Assessment

For hypothesis-testing studies of outcomes and efficiency, we extracted data about the type of HIE, settings, outcomes reported, and results. We classified the type of HIE evaluated in these studies into 3 categories designated by the Office of the National Coordinator for Health Information Technology: query-based, directed, and consumer-mediated (11). We created a separate category for more advanced data exchange functionality, such as HIE-generated alerts (Table 1).

For studies of sustainability, we extracted information about the HIEs under study, study period, method of data collection, and results. For studies of usage, we extracted the same information as for sustainability as well as data on HIE functionality. For studies of attitudes and barriers, we extracted data about the sample and its generalizability, the stakeholders assessed, and the findings. All data extraction was done by 1 reviewer and then independently evaluated by the other. Data for hypothesis-testing studies and descriptive studies of HIE usage were independently extracted by a third reviewer with consensus resolution of discrepancies.

We assessed the quality of hypothesis-testing studies using study design, specification of the HIE, and data

Table 1. Classifications of HIE

HIE Classification	Definition
Direct*	Ability to send and receive secure information electronically between care providers to support coordinated care
Query-based*	Ability for providers to find and/or request information on a patient from other providers, often used for unplanned care
Consumer-mediated*	Ability for patients to aggregate and control the use of their health information among providers
Advanced	Novel data exchange functionalities to facilitate coordination of care across provider organizations (e.g., alerts triggered by an ED visit and sent to the primary care physician and disease-specific care plans shared among the clinical team)

ED = emergency department; HIE = health information exchange.
* Definitions are from reference 12.

about context and implementation. For the latter, we used an existing framework for implementation science (13), context and implementation recommendations specific to health IT (14), and input from HIE experts to select 2 criteria for context (a description of the existing health IT capabilities of the participating providers and previous history of cooperation or engagement at the organizational or community level) and 4 criteria for implementation (local tailoring or iterative process of development or implementation that considered local workflow; the use of an internal or external designated person or persons responsible for implementation, use of clinical champions, or “super users”; a description of efforts to promote awareness and engagement; and other barriers or facilitators not already listed).

For descriptive studies, we assessed quality by the representatives of the sample in terms of geographic area and response rate.

Data Synthesis and Analysis

Because of the variability in HIE characteristics and clinical setting in which they were used, we determined that a meta-analysis was inappropriate. Instead, we constructed evidence tables showing the study characteristics and results for all included studies, organized by outcome measure, and critically analyzed studies to compare their characteristics, methods, and findings. We compiled a summary of findings for each general class of outcome and used them to draw conclusions. We assessed the strength of evidence for hypothesis-testing studies with the Grading of Recommendations Assessment, Development and Evaluation criteria (15).

Role of the Funding Source

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RESULTS

Description of the Evidence

We reviewed 1149 titles and abstracts from the electronic search (including gray literature), 2 articles from content experts, 1 article from a peer reviewer, 148 articles categorized as “health information exchange” or “clinical data exchange” from the related systematic review, and 14 articles from reference mining, for a total of 1314 references. From this, we identified 85 papers on HIE that addressed our study questions. Studies could address more than 1 category. The **Appendix Figure** (available at www.annals.org) details the inclusion of studies and the number of studies related to each key question. The abstracted data for the included articles can be found in **Supplements 2 to 6** (available at www.annals.org). All studies that specified the type of HIE functionality involved query-based HIE. We did not find any evaluations of directed exchange

or consumer-mediated HIE except 1 study that combined query-based and directed exchange and 1 other study that evaluated a nonsustainable, consumer-mediated health bank (16, 17).

Hypothesis-Testing Studies of Effect of HIE on Health Outcomes, Efficiency, Utilization, Costs, and Satisfaction

We identified 12 hypothesis-testing studies that assessed the effect of an HIE organization (**Supplement 2**) (16, 18–28). Eight of these studies focused on emergency care, 2 focused on hospital care, and 2 focused on ambulatory care. One study was a randomized trial, 10 were time-series studies, and 1 was cross-sectional. Nine studies evaluated the effect of an individual HIE organization, and 3 studies assessed large samples of HIEs. The 9 studies of individual HIEs involved 7 distinct HIE organizations, all of which involved only query-based data exchange except 1 (16), which involved query-based exchange, directed exchange, and automated delivery of test results. Most studies reported scant information on context and implementation. The 8 emergency department (ED) studies all evaluated the effect of the HIE on utilization and efficiency, and 7 of 8 found that the HIE was associated with modest to moderate reductions in the use of imaging studies or costs. The only randomized, controlled trial was of an early HIE (now nearly 20 years ago) and found a \$26 mean reduction per encounter in the ED with HIE use. One time-series study of the MidSouth eHealth Alliance found that the HIE was associated with an increase in the use of chest radiography and head computed tomography but a decrease in admissions. The net result was a savings of approximately \$800 000 across 11 hospitals. Two other time-series studies of the same HIE for specific clinical conditions (headache and back pain) found an association with reduced diagnostic imaging studies (odds ratio [OR], 0.38 [95% CI, 0.29 to 0.50]) and increased adherence with guidelines (OR, 1.33 [CI, 1.02 to 1.73]) and 64% lower odds of repeated diagnostic imaging in the emergency evaluation of back pain (6% vs. 21% of patients received repeated lumbosacral spine radiography), but neither study found an association with change in cost of an ED visit, which the authors speculated as being due to confounding by indication in the headache study and a small increase in lumbosacral computed tomography in the back pain study (increase from 1.3% to 2.0% in patients). A time-series study of EDs in California and Florida found that HIE was associated with a reduced probability of repeated imaging studies in the ED for computed tomography (−8.7%), ultrasonography (−9.1%), and chest radiography (−13.0%). In the 1 study that found an association with greater numbers of ED visits, the author interpreted the association to be potentially due to confounding by indication (for example, sicker patients were more likely to have the HIE accessed), for which the analysis could not control (23).

Table 2. Quality of Evidence for Hypothesis-Testing Studies

Outcome Measure	Studies, n	Limitations	Inconsistency	Indirectness	Imprecision	Quality of Evidence
ED efficiency (cost and utilization)	8	Serious	No serious inconsistency	No serious indirectness	Serious	Low
Hospital quality	2	Serious	Serious	Serious	Serious	Very low
Ambulatory care quality	1	Serious	NA	Serious	Serious	Very low
Ambulatory care efficiency	1	Serious	NA	No serious indirectness	Serious	Very low

ED = emergency department; NA = not available.

The 2 hospital studies assessed a national sample of hospitals using existing survey data. One cross-sectional study found no association between participation in an HIE and hospital readmissions, and a time-series study found evidence of a positive association between implementing an HIE and patient satisfaction. The 2 ambulatory studies involved individual HIEs. One study found a 17% decrease in laboratory testing, and the other found that the HIE was associated with an increase from 57% to 64% in a composite of 15 quality measures (22). The latter study found a statistically significant increase in the use of mammography, colorectal cancer, screening, and documentation of body mass index in patients with diabetes and low-density lipoprotein cholesterol levels less than 2.6 mmol/L (100 mg/dL).

All of these studies are limited by 1 or more of the following: choice of study design (for example, a cross-sectional study design generally cannot support causal inference, and time-series studies may not account for secular trends), lack of a clear causal pathway (such as how adoption of HIE may influence patient satisfaction), difficulty in controlling for confounding by indication (patients who are more complex or sick may also be more likely to have HIE accessed), imprecision in the definition of “use” of an HIE (in the studies using existing national surveys), and age (health care and health IT infrastructure older than 20 years). In addition, the body of evidence is limited to 7 specific HIEs. Nevertheless, the results on utilization in the ED are reasonably consistent regarding modest to moderate reductions in imaging or cost, and this was achieved despite information available in the HIE being accessed in a small fraction of the cases. Thus, we concluded that there is low-quality evidence that implementation of an HIE will reduce cost or utilization in the ED (Table 2). The effects of HIE use on other outcomes (quality or satisfaction) and in other settings (hospital or office) have been insufficiently evaluated to draw conclusions.

Descriptive Studies of HIE Usage

Twelve studies reported quantitative descriptions of HIE usage, with data from 10 distinct HIE initiatives (Supplement 3) (29–40). Most of the HIEs in these studies were evaluated in hypothesis-testing studies described previously. Three initiatives came from 1 study of HIEs in New York. Therefore, in all studies, usage data were included in 21 studies of 13 unique HIEs, 6 of which were in

New York. Reports of usage showed wide variation in terms of rates of access, patterns of usage, and types of users. The highest rate of access was reported by an HIE organization in New York, with 60% of patients at 1 site having their data accessed through the HIE. The same study found 1% and 5% access rates in 2 other HIEs in New York. (The 3 New York HIEs had many similarities, including using the same software [29].) That same study suggested that streamlined consent procedures played an important role in 1 HIE’s high access rate compared with the other 2. Typical rates of access ranged from 2% to 10% of visits. Physicians were the primary users in some HIEs, whereas most users were nurses or other staff in other HIEs (29). Two studies from different states found discordant results about the relative use of HIE in hospitals relative to outpatient settings, with imaging data more often accessed from the outpatient setting (38, 40). Another New York study involved automatic querying of the HIE and found that 28% of those queries involved a care transition and therefore included new information for the users (39). (Data on how often users viewed the HIE data were unavailable in that study.)

Like the hypothesis-testing studies, the evidence on usage is limited by the low number of HIEs that have been assessed, which totaled 8. Nevertheless, the rates of use were low compared with estimates of potential opportunities seen (41, 42) in most studies. The high degree of variability in use across different institutions and providers is consistent with patterns found in other health IT applications when they are first introduced, such as electronic prescribing and clinical decision support, and confirms the conclusion that local context and implementation factors are probably important factors (along with software functionality and usability) in promoting high use of an HIE.

Sustainability and Participation in HIE

We identified 17 studies of HIE organizations that investigated issues related to attracting participants and financial sustainability (Supplement 4) (1, 4, 10, 43–56). All but 4 studies were derived from survey data. Of the survey-based studies, we included only the most recent national survey conducted by the eHealth Initiative and 5 other nationwide surveys of HIE organizations. The eHealth Initiative was the most recent (from 2013) and found 135 organizations that facilitate data sharing with

unaffiliated organizations. Only 25 organizations used query-based exchange and 124 used secure messages, whereas all but 1 of the individual HIE organizations reported in this systematic review were exclusively query-based. The eHealth Initiative study also found that many HIEs are not sharing data with competing organizations and that interoperability is a challenge to implement and finance. The most recent of other nationwide surveys, using data from 2012, found that the number of operational HIE organizations is growing, and approximately one quarter of them claim to have a sustainable business model. However, many HIE organizations still struggle to find a value proposition, and it is not clear whether the HIE organizations that are sustainable are centered around the forms of HIE included in this review or more basic forms of data exchange, such as the automated delivery of laboratory results. One nationwide survey found 3 characteristics to be independent predictors of greater financial viability: having ambulatory physicians as receivers of data (adjusted OR of being in a higher category, 4.98; $P = 0.02$), having hospitals as a data receiver (adjusted OR, 4.68; $P = 0.037$), and receiving a 1-time or recurring payment from participants while planning (adjusted OR, 3.43; $P = 0.045$) (44).

Four studies were based on the American Hospital Association survey supplement related to IT and focused only on hospitals. These studies showed that use of HIE increased over time but that larger hospitals were less likely to have implemented an HIE or exchange data for competitive reasons (47, 48, 50, 51).

Four studies focused exclusively on an individual state or HIE: 3 on New York (4, 43, 49) and 1 on Wisconsin (54). In general, these studies showed that fewer than one half of HIEs in existence were actually being used, and many had concerns about sustainability.

The 3 qualitative studies included a history of the shuttered HIE in Santa Barbara, California; a study of a rural HIE in California; and a comparative case study of operational HIEs. These studies identified many sustainability challenges, including competition among regional providers, costs and technical complexity of integrating with an HIE, uncertainty about who benefits, and potential reduction in the need for revenue-generating services (46, 52). The study of the rural HIE identified several successful themes, which the authors speculated were specific to rural HIEs (56).

These studies suggest that attracting participants to HIE and achieving sustainability is complex and may vary widely across the country. Although the number of HIEs that have achieved sustainability grows, many are still at risk for being unsuccessful because of many barriers.

Attitudes, Barriers, and Facilitators

We identified 38 studies of attitudes and barriers, which included 7 studies (57–63) that used national U.S. samples and 30 studies that used regional samples (56,

64–92). The studies reported attitudes and barriers to HIE adoption and use (**Supplement 5**). We rejected 1 national sample study because it reported data that were too old (10 years or greater) to be relevant today (63). Focus groups, surveys, and interviews were used to collect information from physicians, clinicians, patients, policymakers, and other stakeholders. All but 2 of the national U.S. sample studies assessed only the attitude of patients. Two of the national sample studies used random digit dialing, and 2 additional studies analyzed responses to the Health Information National Trends Survey. One study interviewed many stakeholders in 5 representative states. The remaining national U.S. sample study collected interview data from 31 HIE stakeholders. Most regional studies focused on physicians, with data being collected in 22 of 30 studies (71%). Eleven of the regional studies assessed stakeholders in New York, and 4 each of the remaining studies assessed Massachusetts and California stakeholders, with 2 additional studies each from California, Colorado, Minnesota, and Tennessee. Nearly all studies had limitations in their generalizability, either because of the deliberative sampling of stakeholders for interviews or focus groups or poor response rates to surveys, in addition to limited information about context (such as funding or organizational model). Nevertheless, the results of studies are fairly consistent. Although most stakeholders believe that HIE will be valuable to health care, particularly in terms of quality and efficiency, there are many barriers to adoption and use, and these vary somewhat by stakeholder. Physicians and other clinicians most frequently mention concerns about disruptions in workflow, trouble with the interface and other technical problems, and cost to some extent. Policymakers and other stakeholders, principally hospitals or other large providers, worry most about legal and ethical concerns, the plethora of available technology and lack of standards, costs, and the lack of a business case for sustainability. Patients are most concerned about privacy and security and how permission is given to share information. One study relevant to privacy concerns but not included in the evidence table (**Supplement 6**) assessed the correlation between state health disclosure laws and the number of operational HIEs: States that had laws requiring authorization from patients before the disclosure of health information were more likely to have operational HIEs (mean number, 5.3 vs. 2.5; $P = 0.02$) (93).

Advanced Functionality

We found 8 studies of advanced HIE functionality, all of which were descriptive (**Supplement 6**) (73, 94–100). Six of the 8 studies involved alerts of ED or hospital visits or reminders of preventative visits. Of the remaining 2 studies, 1 involved adding a patient portal onto an HIE, and the other involved using HIE data to produce an enhanced laboratory report.

DISCUSSION

The principal findings of this systematic review are that the number of specific HIEs that have been evaluated for evidence of effects on quality, costs, efficiency, usage, and sustainability is few relative to the number of HIEs overall, being just 7 to 10 HIEs, depending on the outcome. Despite this paucity of data, there is reasonably consistent evidence that the use of HIE when it is available is low and likely dependent on context and implementation factors poorly reported in published evaluations; HIE use is associated with reduced costs or utilization in the ED; and the attitudes and barriers to robust and sustainable HIE use are similar to those for many other health IT interventions, which include interface, workflow, and cost issues, as well as patient concerns about privacy. When the large public investments in HIE and its postulated critical importance to health care delivery is considered, more studies are needed to identify what does and does not work and in what contexts (101, 102). Until better evidence is available, all HIEs should be viewed as experiments and evaluated as such.

For the few HIEs that have been studied, evidence suggests that HIE capabilities are generally used in a small portion of patient visits, which is lower than expected given the current fragmentation of care and evidence of missing data in many patient encounters (41, 42, 103, 104). However, usage measures may not capture important components, and consent procedures may be a critical factor (29). More research is needed to create HIE usage metrics so HIEs can be compared for benchmarking and identifying best practices (102, 105). These measures will depend critically on context and technology factors.

Sustainability has been achieved by some HIE organizations, but many are still struggling to find a business case, and the factors for achieving sustainability will likely change over time. Emerging payment models, such as accountable care organizations, bundled payments, and other risk-sharing payment arrangements, may help to create a greater value proposition. Advanced functionalities may also help and need further evaluation. Just as the Internet has spawned myriad ways to exchange data, there is a great opportunity for innovation in HIE (106). New standards and products for directed exchange may facilitate greater data sharing (107) but have not been evaluated. Technical interoperability is also a major barrier.

There are 4 primary limitations to this review. First, we were limited to evaluations that have appeared in published or gray literature. Evaluations of HIEs that were not prepared for a wide audience and those that were may differ. Second, most of the published studies had methodological issues in terms of design, response rates, and generalizability of the enrolled sample. The relative consistency of the principal findings slightly mitigates this methodological concern. In addition, the secular trend with regard to costs, imaging, and laboratory testing is for

increased ordering and costs, thereby making time-series studies showing decreased ordering or reduced cost less likely to be due to secular trends. Third, we were limited by what is reported in these evaluations. As noted, important elements of context and implementation are often missing from the published studies. Fourth, we limited our review to studies in the United States because of our focus on U.S. health IT policy and applications.

In summary, relatively few of the HIE organizations have been evaluated for their effects on outcomes of care. However, the available studies support a low-strength association with reduced utilization and cost in the ED. To increase the benefits on health outcomes of HIE investments, there needs to be more published evaluations of HIEs that use study designs that can support causal inference and that measure and report more details about context and implementation.

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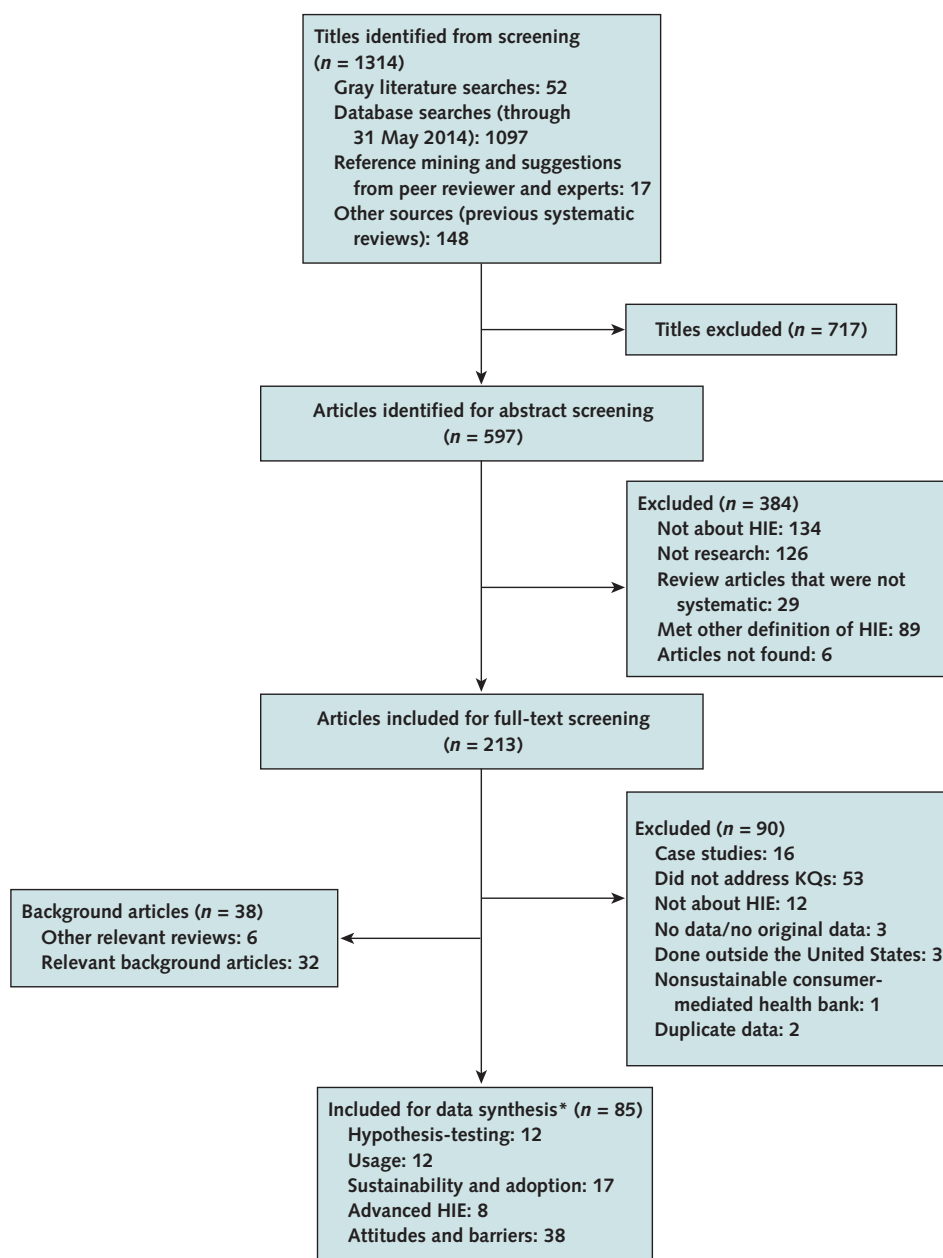
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Appendix Figure. Summary of evidence search and selection.



HIE = health information exchange; KQ = key question.

* Some articles contributed to >1 area.