

Simulation Suggests That Medical Group Mergers Won't Undermine The Potential Utility Of Health Information Exchanges

Robert S. Rudin, Eric C. Schneider, Lynn A. Volk, Peter Szolovits, Claudia A. Salzberg, Steven R. Simon and David W. Bates

(Appeared in *Health Affairs* (2012) vol. 31 (3) pp. 548-59.)

Abstract

Substantial resources are being invested in health information exchanges (HIE), community-based consortia that enable independent health-care organizations to exchange clinical data. However, under pressure to form accountable care organizations, medical groups may merge and support private HIE, reducing the potential utility of community HIEs. Simulations of “care transitions” based on data from 10 Massachusetts communities suggest that mergers would have to be considerable to substantially reduce the potential utility of an HIE. Nonetheless, simulations also suggest that HIEs will need to recruit a large proportion of the medical groups in a community, as hospitals and the largest groups account for only 10 to 20% of care transitions in communities.

Introduction

Health information exchange may be on the verge of a major expansion. Almost two hundred organizations are operating or launching community health information exchanges (HIEs) to enable the exchange of data among healthcare organizations including independent healthcare providers. [1] Community HIEs have the potential to create substantial clinical and financial benefits as a return on the current investment of hundreds of millions of federal and state dollars. [2]

During the next few years, as community HIEs try to become established, the Affordable Care Act will encourage the formation of entities such as accountable care organizations (ACOs) that would integrate formerly independent hospitals and medical groups to form larger entities. Presumably, these entities will support “private HIE.” If the utility of community HIEs is based on their capacity to share patient data across hospitals and physician practices that are independent, the utility of community HIEs could diminish considerably as ACOs are formed, especially if many ACOs operate as closed systems.[3] Medical group mergers are already under way as hospitals and other entities purchase practices, and independent physicians are increasingly shifting toward employed status. [4] [5] The advent of ACOs may accelerate this trend, reducing the number of independent medical groups that would exchange data through a community HIE. [6]

At the same time, community HIEs will face another challenge: recruiting and retaining medical groups. [29] Like a telephone exchange, an HIE is only as good as its participating membership. Independent providers might decline to join an HIE for many reasons, such as concern over competition for patients, technical challenges, privacy and security concerns, legal issues, HIE-related fees, the lack of a business case, and they may not believe an HIE will have relevant information. [7] [8] [9] If few providers in a community contribute data to an HIE, the number of opportunities to use the HIE for improving the coordination and continuity of care will be greatly reduced, and the HIE’s potential utility will be diminished.

This study examines how two factors – (1) the consolidation of hospitals and medical groups into ACOs and (2) the degree of success of HIE recruitment efforts – affect the potential utility of community HIEs. We simulated conditions of consolidation and recruitment using data from ten communities. To measure a community HIE’s potential utility, we used the proportion of relevant *care transitions*, which we identified from administrative claims data, that would be served by the HIE.

Methods

Overview

We used the number of care transitions in a community as a basis for measuring the potential utility of an HIE. A care transition is a sequential pair of patient encounters that involve two different provider groups in a community in which medical records are not shared so that a community HIE might be used to transmit clinical data between the two groups. Sequential visits to two different clinicians within a group were not included because exchange of data could be executed internally through a common medical record, without the need for an HIE.

To simulate the effects of consolidation of medical groups and hospitals and the effects of provider recruitment in an HIE, we analyzed ten geographically-defined communities that were either actively building an HIE or had applied within the past few years to receive a large grant for constructing a community-wide HIE. For each of these communities, we simulated various scenarios of medical group mergers and provider recruitment (described below), assessing the change in the proportion of care transitions that could be covered by an HIE under each scenario.

Data Sources

We obtained administrative claims data for members of a major private insurer, which had a larger market share, in 10 geographical communities in Massachusetts. The data set included all claims, paid and unpaid, from January 1st 2005 through June 30th 2009, which were submitted to the insurer by providers who practiced within the zip codes of the communities. We divided the data set into three 18-month periods to test for consistency of the results, and for each study period we included only patients enrolled for the duration of the study period. The data set also included demographic information about the providers from the end of the final study period, which we used to assign providers to medical groups (Appendix 1). We performed the entire analysis including all clinical specialties and also performed a separate analysis for only “core” provider specialties, those in which the providers were likely to be frequent HIE users. This core group included most physician specialties and nurses. We excluded radiologists and pathologists from the core specialties because those providers tend to have high volumes of care transitions which would dominate the simulation results and interfere with closer examination of data exchanges among the other specialties.

Measuring Care Transitions

We used claims data to identify provider visits. Multiple claims with the same date, medical group and patient were considered part of the same visit. All claims that occurred during an inpatient visit were considered part of the one visit to an assigned hospital in the community. We excluded all claims labeled as facilities fees and any other claims not labeled “professional.” A care transition was identified based on the sequence of provider visits and was counted if the patient’s preceding medical visit was to a different medical group. Repeat visits to the same group without intervening visits to other providers were not counted as care transitions (Exhibit 1). This measure is similar to the “sequence” metric used by researchers to estimate continuity of care. [10] It is an estimate of the number of times that community providers would potentially access an aggregate longitudinal patient record stored within a community HIE. [3]

To estimate potential utility of the HIE, we computed the total number of patients’ care transitions between the medical groups which were assumed to be participating in the community HIE under each simulated scenario. For each of the ten communities, we computed the baseline number of care transitions by assuming that all included medical groups participated in their community HIE and none of them had merged. The specific simulation patterns generated for both medical group mergers and for provider recruitment are described below.

Simulations

We performed two simulations that generated scenarios of medical group mergers and two more simulations that generated scenarios of varied provider recruitment.

Simulation 1: Large group mergers. This simulation shows the cumulative impact of mergers among hospitals and the largest medical groups on the proportion of care transitions available to the HIE. After computing the baseline number of care transitions that occurred in one study period assuming full participation by community medical groups, this simulation then computes the number of care transitions that would be covered by the HIE if the two groups that share the most care transitions between them had merged. A merger of these two groups would reduce the number of care transitions covered by the HIE more than any other merger. The simulation then repeats until all of the groups have merged into one community-wide group with zero care transitions.

Simulation 2: Small group mergers. Simulation 2 examines the cumulative effect of mergers of smaller groups on the proportion of care transitions available to the HIE. Merged groups are selected by taking the group with the smallest number of visits in the data set and merging it with the group with which it shares the largest number of care transitions. Like simulation 1, this simulation repeats until all groups merge into one community-wide group.

Simulation 3: Recruitment. Simulation 3 assesses the effect of an increase in the participation of medical groups on the proportion of care transitions handled by the HIE. Starting with a single participating group, the number of care transitions covered by the HIE is zero and increases with each additional group. This simulation begins with the medical group that is involved in the most care transitions in the community and iteratively adds the group involved in the next most volume of care transitions until it reaches the baseline case of all groups participating. It therefore reflects one case of how HIEs may recruit medical groups.

Simulation 4: Retention. Simulation 4 assumes full community participation and then simulates the non-participation of only the group that is involved in the most care transitions in the community. Using the same sequence of groups as simulation 3, it then iteratively simulates the non-participation of the group involved in the next most volume of care transitions until none of the groups are remaining. This simulation shows how many “key” groups exist in each community without which the HIE’s potential utility would be substantially reduced. It is analogous to a targeted attack on a network in which the nodes that would reduce the network’s potential utility by the greatest degree are attacked and removed from the network one at a time. [11]

For each simulation, we only varied either the group structure (simulations 1 and 2) or which groups participated in the HIE (simulations 3 and 4). The time period was kept constant for every scenario within each simulation. Holding the simulation time periods constant allows an examination of the effect of our two phenomena on potential HIE utility, but does not represent realistic merging and recruitment events which would occur over time.

We performed the four simulations on the claims data for each of the ten communities, separately for core providers and for all providers, and for each of the three study periods. We executed the simulations using MATLAB version 7.9.0 (R2009b) on a high performance computing cluster.

Analysis

For each community, we computed the number of study patients, total visits, visits per patient, and number of medical groups including hospitals and their emergency departments. Visits to the ED in which the patients were admitted to the hospitals were counted as part of the same visit. We also computed the transition percentage – defined as the proportion of total community visits for which the previous visit in the community was to a different medical group.[3] To calculate market concentration, we used the Herfindahl-Hirschman Index (HHI) which ranges from near 0 (many small firms) to 1 (only one large firm). The HHI is computed by squaring the market share of each group in the community and then summing the resulting numbers. To represent the market share of each group, we used the number of patient visits to that group during the study period.

For each simulation, we computed specific metrics that summarize the results. We computed the median and range of results across the communities, and compared the results across the three study periods, for both core specialties and all specialties. We normalized the results based on the number of medical groups in each community, which we calculated as the number of groups that would account for 99% of community care transitions. This excluded the smallest groups because they would not have much of an impact on the potential utility of the HIE.

In each community, we also examined the potential utility of the key hospitals or medical groups – defined as those that were involved in the most community care transitions – by reporting the potential utility of the HIEs when only those providers were participating compared to how much they would reduce the HIE’s potential utility if they were the only groups that did not participate.

Results

Community characteristics

The communities varied widely along several characteristics (Exhibit 2). There was a five-fold variation in the number of study patients per community, and an eight-fold variation in the number of medical groups per community. The number of visits per patient to core providers ranged between 3.6 and 6.1. The transition percentage (the percentage of sequential encounters that involved distinct providers) also varied substantially across the study communities ranging from approximately 30% to 50% for core providers. The concentration of encounters among providers differed by a factor of more than 6 among the communities for core specialties. The community with the fewest patients (community number 10; Exhibit 2) was also the most concentrated by a substantial degree.

Simulation results

The ten communities showed modest variation in their potential utility under the simulation scenarios we used (Exhibit 3). The results and analysis of the three study periods and for all provider specialties is available in Appendix 2. In all communities, simulation 1 results show that the potential utility of HIEs is not greatly affected by large group mergers: for core specialties the number of groups could be reduced by 20% to 36% through the most high-impact mergers (via 6 to 41 mergers) before potential utility would be reduced below 50% (Exhibit 4). Under the pattern of consolidation in simulation 2 in which smaller groups merged into larger ones, as long as there were

between 4 and 9 groups remaining (3 to 13% of the number of original groups), an HIE would still have 50% of its potential utility (Exhibit 5).

The provider recruitment simulation showed that a substantial number of groups would need to be recruited for an HIE to have substantial potential utility: to achieve 50% of the HIE's potential utility, a median of 18.5 groups (ranging 6 to 35 or 18% to 36%) of total community medical groups would need to participate (Exhibit 6). Conversely, the HIE would be limited to 50% of its potential if it failed to retain a relatively small number of key groups, 2 to 10 groups which consist of 5% to 13% of the total community medical groups (Exhibit 7). If these 2 to 10 key groups were the only groups recruited, the HIE would realize only 10 to 20% of its potential utility (Exhibit 8). The communities would have to recruit approximately 2 and 4 times the number of these key groups to achieve 50% of their potential utility.

Discussion

We simulated the impact of medical group consolidation and varying degrees of success in provider recruitment in HIEs on the potential utility of HIEs in ten geographically-defined communities. Our results suggest that with the exception of communities in which providers are highly concentrated, mergers of medical groups into ACOs would not substantially reduce the potential utility of community HIEs. Furthermore, considerable consolidation of smaller providers could occur without diminishing the HIE's potential utility substantially. However, our results also suggest that participation by hospitals and other key medical groups may not be sufficient for HIEs to achieve their potential utility. It appears that these key providers are involved in many care transitions with other medical groups in the community but relatively few care transitions with one another.

Few other studies examine the potential utility of HIE by investigating patient patterns of encounters, and those have been limited mainly to emergency or acute care facilities.[12] [13] [14] Other studies have investigated care fragmentation by counting the number of different providers that patients visit in a given year and how providers are linked to other providers via shared patients. [15] [16] [17] However, these studies do not consider care transitions, an important additional dimension for estimating potential utility of HIEs.

Even though the ten study communities were located in Massachusetts, the communities' characteristics differed notably, suggesting they may represent at least some of the diversity found in other parts of the U.S. For example, the number of visits per patient varied nearly 2-fold, which may reflect differences in patient visit patterns and crossover with providers in neighboring communities. Also, the transition percentage varied substantially across the communities. These variations may reflect differences in group structure, provider specialties, patient visit patterns, or differences in other patient or provider characteristics among the communities. The market concentration also varied considerably.

The findings in this study may be relevant to some of the key issues facing HIEs today, including working with accountable care organizations, recruiting a critical mass of providers, and paying for HIE services.

Accountable Care Organizations

While our study shows that an HIE may still be important even if there are many mergers, ACOs may create incentives for enough mergers in some communities to challenge the utility of an HIE because of a decrease in antitrust restrictions and because larger groups may be more efficient in delivering higher quality care. [18] On the other hand, some providers may want to have control of their patients' data should they decide to leave an ACO, and a merger in which providers adopt the same EHR would not allow that kind of flexibility.[19] It is therefore unknown at this point if medical groups will merge and adopt shared EHRs on a scale that would pose a substantial threat to the utility of HIEs.

How ACOs and HIEs will be structured is also unknown. [6] [20] [21] Some communities may have one community-wide ACO whose medical groups all participate in the same private HIE; other communities may have multiple ACOs which share the same community HIE even for their internal data exchanges; [19] and others may involve more complex arrangements in which individual medical groups participate in multiple ACOs or multiple HIEs. Regardless, in many communities, ACOs and HIEs will need to work together to achieve their goals of improving care quality and reducing cost.

ACOs and HIEs with high rates of “leakage” or “crossover” of patient visits with neighboring communities may have difficulty determining which collection of medical groups would optimize their ability to coordinate care effectively and maximize HIE utility. Because regulations will not restrict Medicare patients from seeking care outside of an ACO, patient crossover may not be reduced in the near future. [20] However, there may be significant advantages for patients if they stay within the same HIE or ACO, such as improved coordination of care, and better measurements of provider quality. HIEs, ACOs, and policymakers should consider how to motivate patients to stay within their participating medical groups, perhaps through tiered copayments. [22]

Even so, there will likely always be a need for ACOs or HIEs to share data with external providers. In communities in which one ACO with a private HIE dominates, the ACO may attempt to “lock in” patients by restricting clinical exchange to only their providers, even if many patients receive care externally. This may be especially true for early-stage ACOs, which are still paid primarily using a fee-for-service model. Policies must ensure that ACOs share data with other ACOs as appropriate. This may be less of a concern for later stage ACOs whose payment depends heavily on quality measures and, therefore, have an incentive to share data if it would improve care quality.

Critical mass of providers

Many HIEs begin with only a few large hospitals and large provider groups. [23] [9] [14] [24] Small practices have been slow to participate. [25] Our results suggest that hospitals and other larger medical groups are key, but they may not constitute a critical mass for many communities. Therefore, HIEs will need to recruit many smaller providers to realize most of their potential utility. [26]

To help with recruitment, incentives and workflow interventions may need to be customized to different kinds of providers. Hospitals and larger groups may be more worried about sharing data with competitors, and may therefore be a particularly good target for either strong incentives and/or close monitoring that data are actually being contributed. [7] [8] The barriers for smaller groups, by contrast, may relate to different factors such as lack of technical expertise and they may need considerable technical

support. [27] Many medical groups will likely require training in how to integrate the HIE into their workflows. [28] [29] Meaningful use payments may accelerate HIE adoption for many medical groups, but they may be more effective for some types of groups than others. [30] [31]

Who should pay for HIE?

If HIE can be shown empirically to reduced costs or improve quality, payers may create incentives that encourage the medical groups with whom they contract to participate in HIEs. [2] An analysis of the effect of each group's participation on potential HIE utility, similar to what we do in the recruitment and retention simulations (simulations 3 and 4), could help inform the payment rates with empirical justification and provide a better estimate of value compared with a flat fee per physician. [32] To avoid free-riding among payers, all the major payers in a community may need to coordinate to perform this kind of analysis, perhaps via a third party, so that HIE payment rates are fairly distributed among the payers. This kind of differential fee schedule may be especially important for communities that contain large medical groups that provide comprehensive care for many patients (e.g. Kaiser Permanente) because they may employ many physicians but have relatively little need for HIE because of their patients' visit patterns.

As HIE technology improves, providers may be more willing to pay for HIEs themselves, especially if they find HIEs save them time and helps them deliver better care, which may improve their chances of receiving payments based on quality measures. Providers may then have an interest in adopting a differential fee schedule for HIE instead of payers. Estimates of potential utility of HIE based on care transitions may be more effective as the basis of payment compared with requiring providers to pay for each HIE access because that would involve a disincentive for accessing the HIE.

Limitations

This study was limited to patients younger than 65 years who were continuously enrolled with one private payer, and to providers with office addresses within ten communities in Massachusetts. None of the communities included a major urban center. The payer's market penetration may have varied across the communities, thereby limiting the comparability of the communities. We did not verify the provider assignments to their medical groups, and we assumed all providers stayed in the same groups for all three study periods. The method we used to assign providers to groups may have overestimated medical group fragmentation by separating those clinicians who share an EHR but reside in different suites or addresses, or underestimated fragmentation by combining those clinicians who reside in the same suite or address but use separate EHRs. We likely overestimated the number of medical groups in each community because many providers had few visits. Potential utility as estimated by care transitions may be very different from actual utility because providers may not use an HIE for every care transition. We did not stratify types of care transitions by utility or value because we could find any studies that created such a stratification. However, some types of data exchange are clearly more important than others. Our study is also limited to the aggregate patient record form on HIE; we did not model other forms of HIE, such as point-to-point data exchange between medical groups. [33]

Finally, for all simulations, we used the total care transitions which occurred in the community as the denominator for estimated potential utility. However, HIEs may also be interested in maximizing the percentage of care transitions covered by the HIE for only participating providers or using other metrics to evaluate their success.

Conclusions

In this early study of the care transitions and potential utility of community HIEs, we analyzed visit patterns of patients enrolled with one private payer. Our findings suggest that, for many communities, mergers between medical groups will not threaten HIE's potential utility unless many of them occur. Therefore it would be prudent to continue to invest in HIEs. However, our results also suggest that while most communities contain a few key medical groups that would be critical participants in an HIE, they would likely not be sufficient to achieve most of the HIE's potential utility in the community. Additional incentives – carrots or sticks – may be necessary to ensure that enough groups participate in HIEs for them to realize their potential.

This study demonstrates that an analysis of patient visit patterns can provide important insights into the utility of HIEs. Individual HIEs may benefit from performing similar analyses as they grapple with issues related to working with ACOs, provider recruitment, and financial sustainability.

REFERENCES

- [1] 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 May;154(10):666–671. Available from: <http://dx.doi.org/10.1059/0003-4819-154-10-201105170-00006>.
- [2] Walker J, Pan E, Johnston D, Adler-Milstein J, Bates DW, Middleton B. The value of health care information exchange and interoperability. *Health Aff (Millwood)*. 2005;Suppl Web Exclusives:W5–10–W5–18. Available from: <http://dx.doi.org/10.1377/hlthaff.w5.10>.
- [3] Rudin RS, Salzberg CA, Szolovits P, Volk LA, Simon SR, Bates DW. Care transitions as opportunities for clinicians to use data exchange services: how often do they occur? *J Am Med Inform Assoc*. 2011 Apr; Available from: <http://dx.doi.org/10.1136/amiajnl-2010-000072>.
- [4] Casalino LP, Pham H, Bazzoli G. Growth of single-specialty medical groups. *Health Aff (Millwood)*. 2004;23(2):82–90.
- [5] Isaacs SL, Jellinek PS, Ray WL. The independent physician—going, going.... *N Engl J Med*. 2009 Feb;360(7):655–657. Available from: <http://dx.doi.org/10.1056/NEJMp0808076>.
- [6] Fisher ES, Shortell SM. Accountable care organizations: accountable for what, to whom, and how. *JAMA*. 2010 Oct;304(15):1715–1716. Available from: <http://dx.doi.org/10.1001/jama.2010.1513>.
- [7] Vest JR. More than just a question of technology: Factors related to hospitals' adoption and implementation of health information exchange. *Int J Med Inform*. 2010 Dec;79(12):797–806. Available from: <http://dx.doi.org/10.1016/j.ijmedinf.2010.09.003>.
- [8] Grossman JM, Kushner KL, November EA. Creating Sustainable Local Health Information Exchanges: Can Barriers to Stakeholder Participation be Overcome? Center for Studying Health System Change. 2008; Research brief.
- [9] Miller RH, Miller BS. The Santa Barbara County Care Data Exchange: what happened? *Health Aff (Millwood)*. 2007;26(5):w568–w580. Available from: <http://dx.doi.org/10.1377/hlthaff.26.5.w568>.
- [10] Jee SH, Cabana MD. Indices for continuity of care: a systematic review of the literature. *Med Care Res Rev*. 2006 Apr;63(2):158–188. Available from: <http://dx.doi.org/10.1177/1077558705285294>.
- [11] Albert R, Jeong H, Barabási AL. Error and attack tolerance of complex networks. *Nature*. 2000;406:378–382.
- [12] Bourgeois FC, Olson KL, Mandl KD. Patients treated at multiple acute health care facilities: quantifying information fragmentation. *Arch Intern Med*. 2010 Dec;170(22):1989–1995. Available from: <http://dx.doi.org/10.1001/archinternmed.2010.439>.
- [13] Finnell JT, Overhage JM, Dexter PR, Perkins SM, Lane KA, McDonald CJ. Community clinical data exchange for emergency medicine patients. *AMIA Annu Symp Proc*. 2003;p. 235–238.

- [14] Vest JR, Zhao H, 'jon Jaspersen, Gamm LD, Ohsfeldt RL. Factors motivating and affecting health information exchange usage. *J Am Med Inform Assoc.* 2011 Jan; Available from: <http://dx.doi.org/10.1136/jamia.2010.004812>.
- [15] Pham HH, Schrag D, O'Malley AS, Wu B, Bach PB. Care patterns in Medicare and their implications for pay for performance. *N Engl J Med.* 2007 Mar;356(11):1130–1139. Available from: <http://dx.doi.org/10.1056/NEJMsa063979>.
- [16] Pham HH, O'Malley AS, Bach PB, Saiontz-Martinez C, Schrag D. Primary care physicians' links to other physicians through Medicare patients: the scope of care coordination. *Ann Intern Med.* 2009 Feb;150(4):236–242.
- [17] Hussey PS, Sorbero ME, Mehrotra A, Liu H, Damberg CL. Episode-based performance measurement and payment: making it a reality. *Health Aff (Millwood).* 2009;28(5):1406–1417. Available from: <http://dx.doi.org/10.1377/hlthaff.28.5.1406>.
- [18] Berenson RA, Ginsburg PB, Kemper N. Unchecked provider clout in California foreshadows challenges to health reform. *Health Aff (Millwood).* 2010 Apr;29(4):699–705. Available from: <http://dx.doi.org/10.1377/hlthaff.2009.0715>.
- [19] Rudin RS, Simon SR, Volk LA, Tripathi M, Bates D. Understanding the decisions and values of stakeholders in health information exchanges: experiences from Massachusetts. *Am J Public Health.* 2009 May;99(5):950–955. Available from: <http://dx.doi.org/10.2105/AJPH.2008.144873>.
- [20] Berwick DM. Launching Accountable Care Organizations - The Proposed Rule for the Medicare Shared Savings Program. *N Engl J Med.* 2011 Mar; Available from: <http://dx.doi.org/10.1056/NEJMp1103602>.
- [21] McClellan M, McKethan AN, Lewis JL, Roski J, Fisher ES. A national strategy to put accountable care into practice. *Health Aff (Millwood).* 2010 May;29(5):982–990. Available from: <http://dx.doi.org/10.1377/hlthaff.2010.0194>.
- [22] Sinaiko AD, Rosenthal MB. Consumer experience with a tiered physician network: early evidence. *Am J Manag Care.* 2010 Feb;16(2):123–130.
- [23] McDonald CJ, Overhage JM, Barnes M, Schadow G, Blevins L, Dexter PR, et al. The Indiana network for patient care: a working local health information infrastructure. An example of a working infrastructure collaboration that links data from five health systems and hundreds of millions of entries. *Health Aff (Millwood).* 2005;24(5):1214–1220.
- [24] Hincapie AL, Warholak TL, Murcko AC, Slack M, Malone DC. Physicians' opinions of a health information exchange. *J Am Med Inform Assoc.* 2011 Jan;18(1):60–65. Available from: <http://dx.doi.org/10.1136/jamia.2010.006502>.
- [25] Fontaine P, Zink T, Boyle RG, Kralewski J. Health information exchange: participation by Minnesota primary care practices. *Arch Intern Med.* 2010 Apr;170(7):622–629. Available from: <http://dx.doi.org/10.1001/archinternmed.2010.54>.
- [26] Rudin RS. The litmus test for health information exchange success: will small practices participate?: comment on "health information exchange". *Arch Intern Med.* 2010 Apr;170(7):629–630. Available from: <http://dx.doi.org/10.1001/archinternmed.2010.59>.
- [27] Bates DW, Ebell M, Gotlieb E, Zapp J, Mullins HC. A proposal for electronic medical records in U.S. primary care. *J Am Med Inform Assoc.* 2003;10(1):1–10.

- [28] DesRoches CM, Campbell EG, Rao SR, Donelan K, Ferris TG, Jha A, et al. Electronic health records in ambulatory care—a national survey of physicians. *N Engl J Med*. 2008 Jul;359(1):50–60. Available from: <http://dx.doi.org/10.1056/NEJMsa0802005>.
- [29] Rudin RS, Volk LA, Simon SR, Bates DW. What Affects Clinicians' Usage of Health Information Exchange? *Applied Clinical Informatics*. 2011;2:250–262.
- [30] Blumenthal D, Tavenner M. The "meaningful use" regulation for electronic health records. *N Engl J Med*. 2010 Aug;363(6):501–504. Available from: <http://dx.doi.org/10.1056/NEJMp1006114>.
- [31] Department of Health and Human Services. Final Rule; 2010. Available from: http://www.ofr.gov/OFRUpload/OFRData/2010-17207_PI.pdf (accessed July 2010).
- [32] Wright A, Soran C, Jenter CA, Volk LA, Bates DW, Simon SR. Physician attitudes toward health information exchange: results of a statewide survey. *J Am Med Inform Assoc*. 2010;17(1):66–70. Available from: <http://dx.doi.org/10.1197/jamia.M3241>.
- [33] The Direct Project;. Available from: <http://directproject.org/> (accessed February 20, 2011).

One patient's visit sequence to medical groups A, B and C	Baseline no. of care transitions	No. care transitions covered by HIE if groups A and B merged	No. care transitions covered by HIE if group C was not participating
AAAAAAAAAA	0	0	0
ABABABABAB	9	0	9
AAAAABBBBB	1	0	1
ABCAACABBA	7	4	4

Exhibit 1. Example patient visit sequences and corresponding number of care transitions covered by an HIE.

Source: Authors.

Notes: Care transitions are opportunities for participating providers to access new data in the aggregate patient records of a community HIE.

Community ²	No. patients	No. visits ³	Visits/patient	No. transitions	Transition percentage ⁴	HHI	No. groups
1	51,434	295,460	5.74	138,114	46.75%	0.0225	182
2	19,436	88,470	4.55	29,817	33.70%	0.0329	72
3	46,911	191,828	4.09	70,662	36.84%	0.0372	107
4	20,538	126,028	6.14	63,139	50.10%	0.0394	62
5	49,040	217,304	4.43	76,680	35.29%	0.0401	101
6	56,799	225,887	3.98	81,857	36.24%	0.0405	105
7	40,001	144,048	3.60	45,273	31.43%	0.0409	76
8	17,896	70,856	3.96	30,783	43.44%	0.0453	38
9	16,740	75,678	4.52	22,532	29.77%	0.0715	34
10	9,856	54,395	5.52	23,596	43.38%	0.1421	22
median[min-max]	30,269.5[9,856-56,799]	135,038.[54,395-295,460]	4.48[3.60-6.14]	54,206.[22,532-138,114]	36.54%[29.77%-50.10%]	0.0403[0.0225-0.1421]	74[22-182]

Exhibit 2. Community characteristics table (core specialties only).¹

Source: Simulation of care transitions in ten Massachusetts communities.

Notes:

1. Includes visits to core specialties from patients who were fully enrolled with one private payer from January 1st 2005 until June 30th 2006.
2. Communities are presented here in order of increasing Herfindahl-Hirschman index (HHI)
3. Excludes each patient's initial visit in the study period because there is no way to determine if that visit involved a care transition.
4. Transition percentage is defined as the percent of total visits to community providers for which the patient's previous visit was to a different medical group in the community.

Community ¹	No. groups ²	Simulation 1		Simulation 2		Simulation 3		Simulation 4		No. group absences which would reduce potential HIE usage by > 50% ^{5,6}
		No. big mergers which would reduce potential HIE usage by > 25% ³	No. big mergers which would reduce potential HIE usage by > 50% ³	No. consolidated groups needed for potential HIE to be > 30% ⁴	No. consolidated groups needed for potential HIE to be > 50% ⁴	No. groups needed to participate to achieve 15% potential HIE usage ^{5,6}	No. groups needed to participate to achieve 50% potential HIE usage ^{5,6}	Reduction in potential HIE usage from absence of 2 groups ^{5,6}	Reduction in potential HIE usage from absence of 5 groups ^{5,6}	
1	182	18	41	4	7	8	35	17.66%	34.27%	10
2	72	12	24	4	9	7	23	28.01%	46.51%	7
3	107	12	25	4	7	7	23	23.37%	41.32%	8
4	62	8	17	2	4	5	15	29.43%	52.51%	5
5	101	10	23	4	7	6	22	25.41%	43.09%	7
6	105	10	22	3	5	6	20	25.12%	46.60%	6
7	76	9	18	6	8	6	17	27.92%	50.81%	5
8	38	8	14	4	7	6	13	30.12%	51.70%	5
9	34	7	13	3	6	5	13	37.12%	62.36%	3
10	22	2	6	2	4	2	6	63.52%	82.35%	2
median[min- max]	74[22-182]	9.5[2-18]	20.[6-41]	4.[2-6]	7.[4-9]	6.[2-8]	18.5[6-35]	27.97%[17.66%- 63.52%]	48.70%[34.27%- 82.35%]	5.5[2- 10]

Exhibit 3. Summary results (core specialties only from January 1st 2005 until June 30th 2006)

Source: Simulation of care transitions in ten Massachusetts communities.

Notes:

1. Communities are presented here in order of increasing Herfindahl-Hirschman index (HHI)
2. No. groups are those that constitute 99% of community care transitions.
3. The sequence of mergers was decreasing by number care transitions between the pairs of medical groups in each geographic community.
4. Consolidation was simulated by iteratively merging groups that had the smallest visit volumes into the groups with which they shared the most care transitions.
5. The sequence of the groups is decreasing by volume of care transitions in each geographic community.
6. The denominator for these percentages is the potential HIE usage for the study period in each community assuming complete participation and no mergers i.e. the total number of care transitions between groups during the study period.

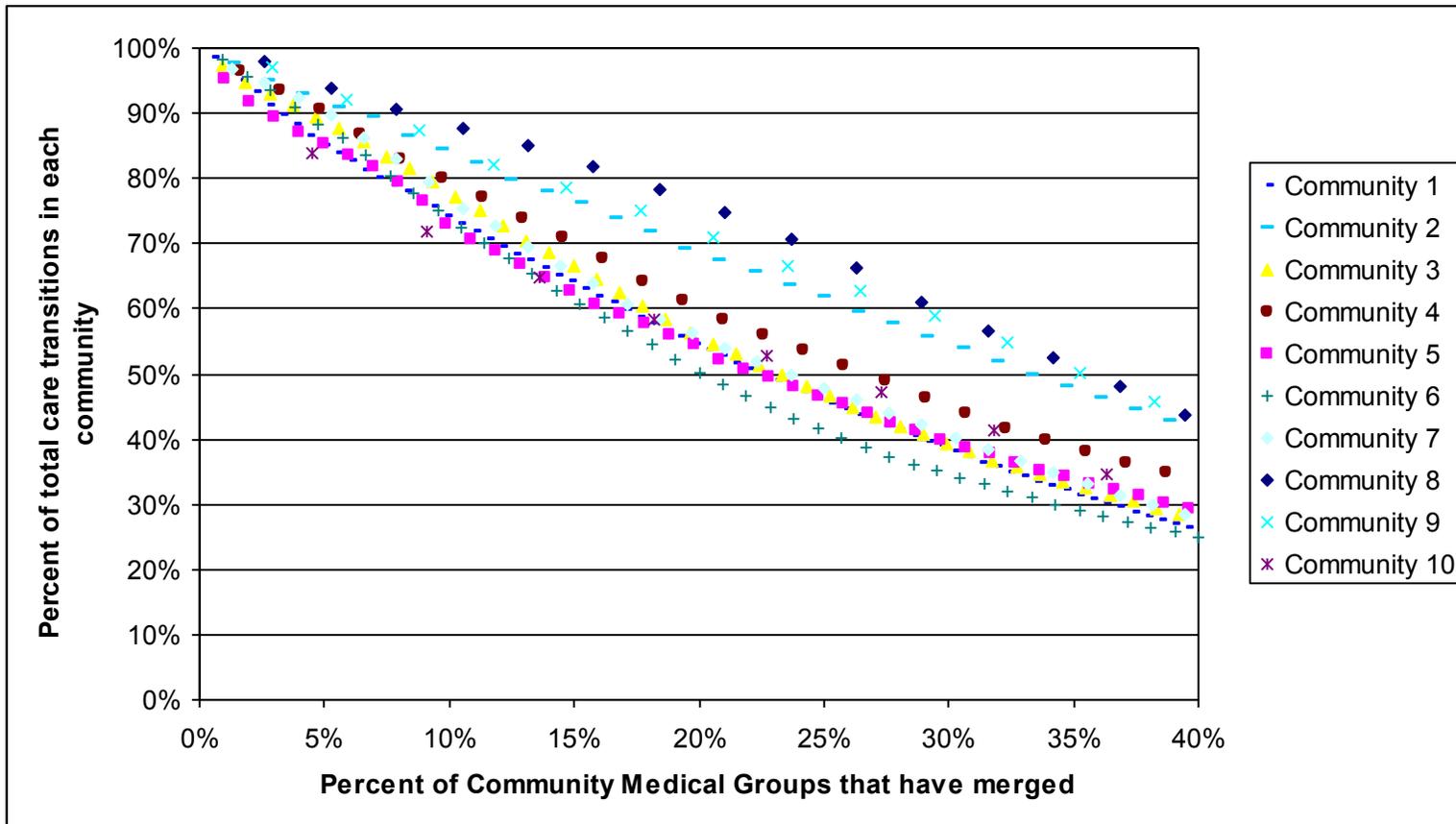


Exhibit 4. Larger mergers (simulation 1, for core specialties only).

Source: Simulation of care transitions in ten Massachusetts communities.

Notes:

This pattern simulates the effect of mergers of medical groups on the potential utility of community HIEs. Groups are chosen to merge based on the pairs of groups with the most care transitions between them and so the first merger has the largest effect. The data include only core specialties and patient visits from January 1st 2005 through June 30th 2006. (Note: The x-axis represents a contrived pattern of variation in medical group mergers, and does not represent time. Every data point simulates all patient visits for the entire the study period.)

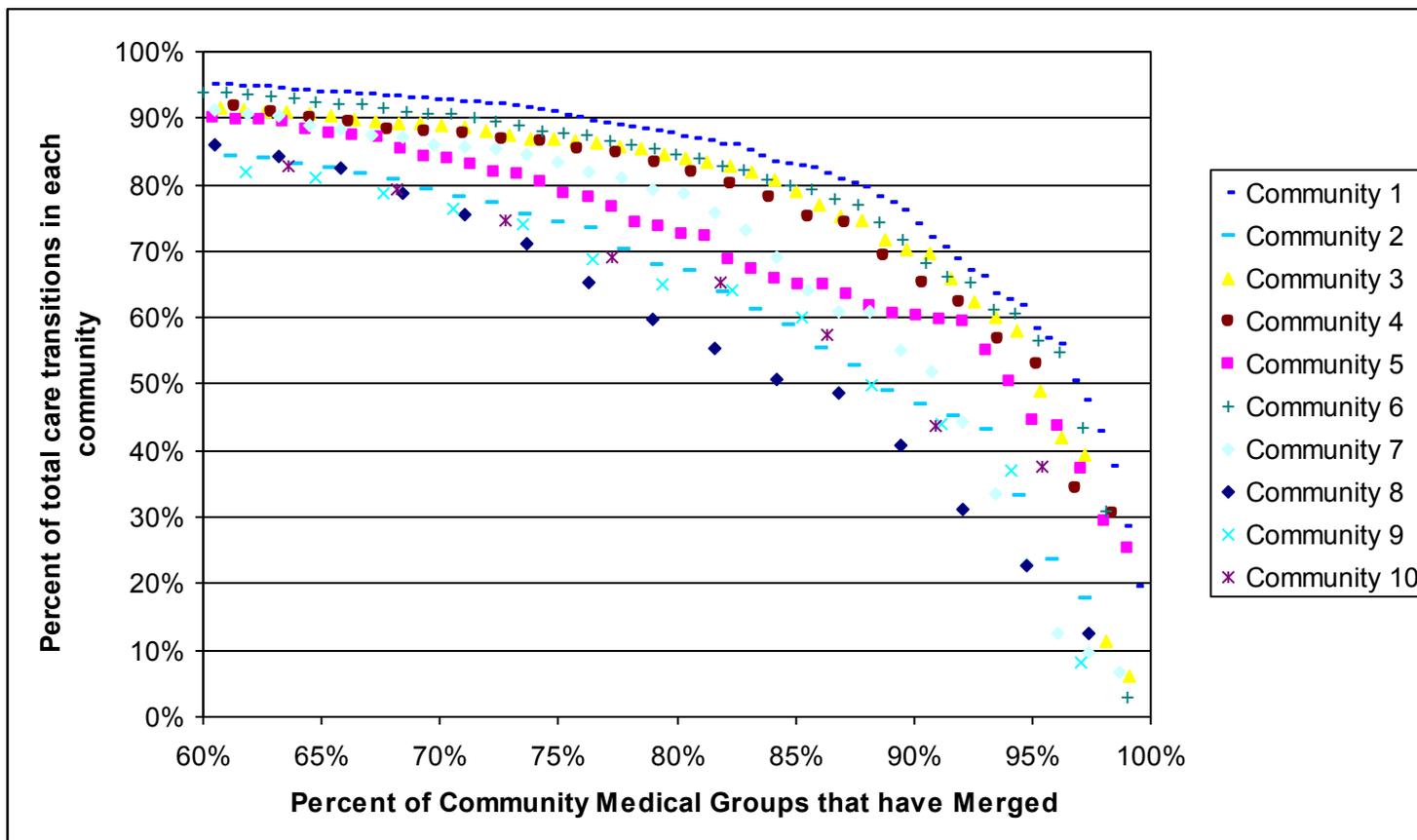


Exhibit 5. Small mergers (simulation 2, for core specialties only).

Source: Simulation of care transitions in ten Massachusetts communities.

Notes:

This pattern simulates the effect of mergers of medical groups on the potential utility of community HIEs. Groups with the smallest visit volumes are chosen to merge with the group with whom they share the most care transitions and so the first mergers tend to have small effects. The data include only core specialties and patient visits from January 1st 2005 through June 30th 2006. (Note: The x-axis represents a contrived pattern of variation in medical group mergers, and does not represent time. Every data point simulates all patient visits for the entire the study period.)

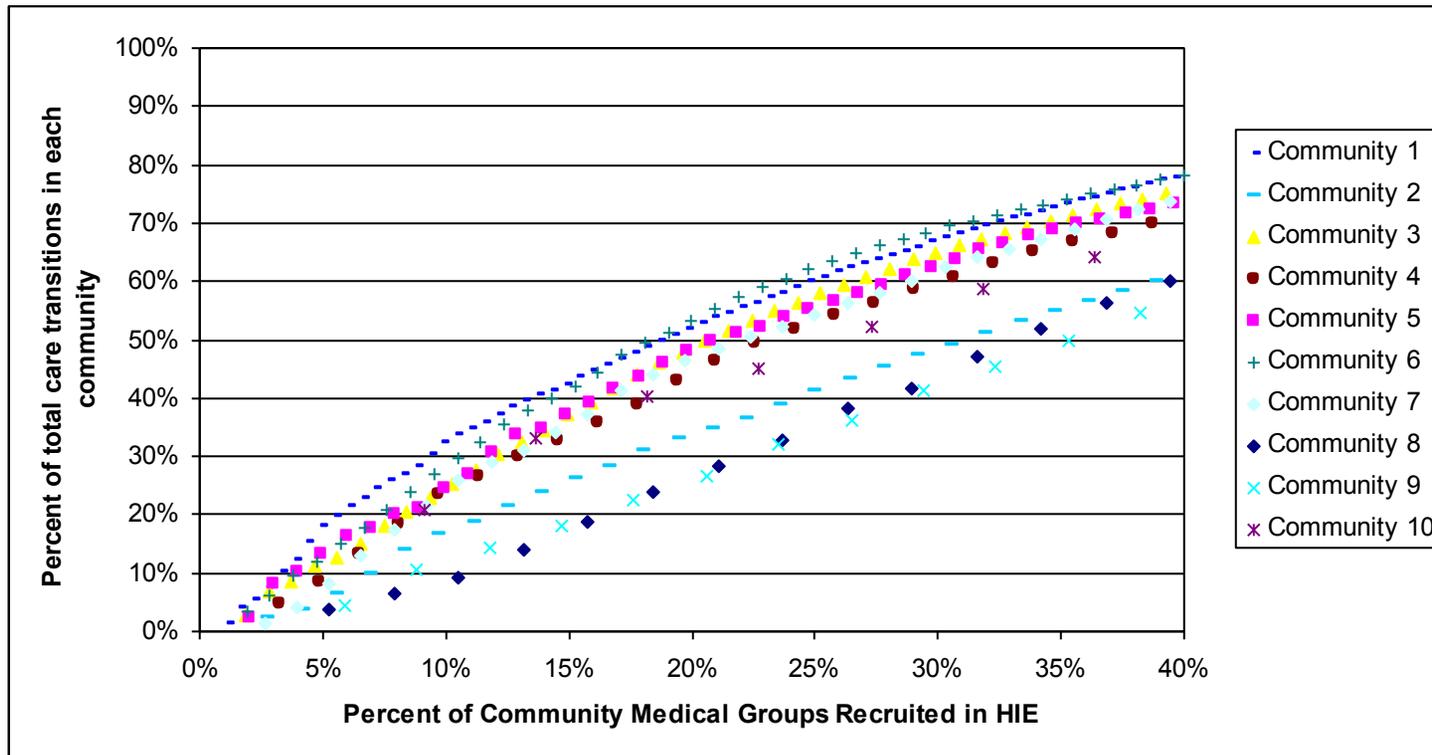


Exhibit 6. Recruitment (simulation 3, for core specialties only).

Source: Simulation of care transitions in ten Massachusetts communities.

Notes:

This pattern simulates the effect of medical group participation in community HIEs on the potential utility of the HIEs beginning with one group participating. The sequence of groups is determined by decreasing volume of care transitions in each community. The data include only core specialties and patient visits from January 1st 2005 through June 30th 2006. (Note: The x-axis represents a contrived pattern of variation in medical group mergers, and does not represent time. Every data point simulates all patient visits for the entire the study period.)

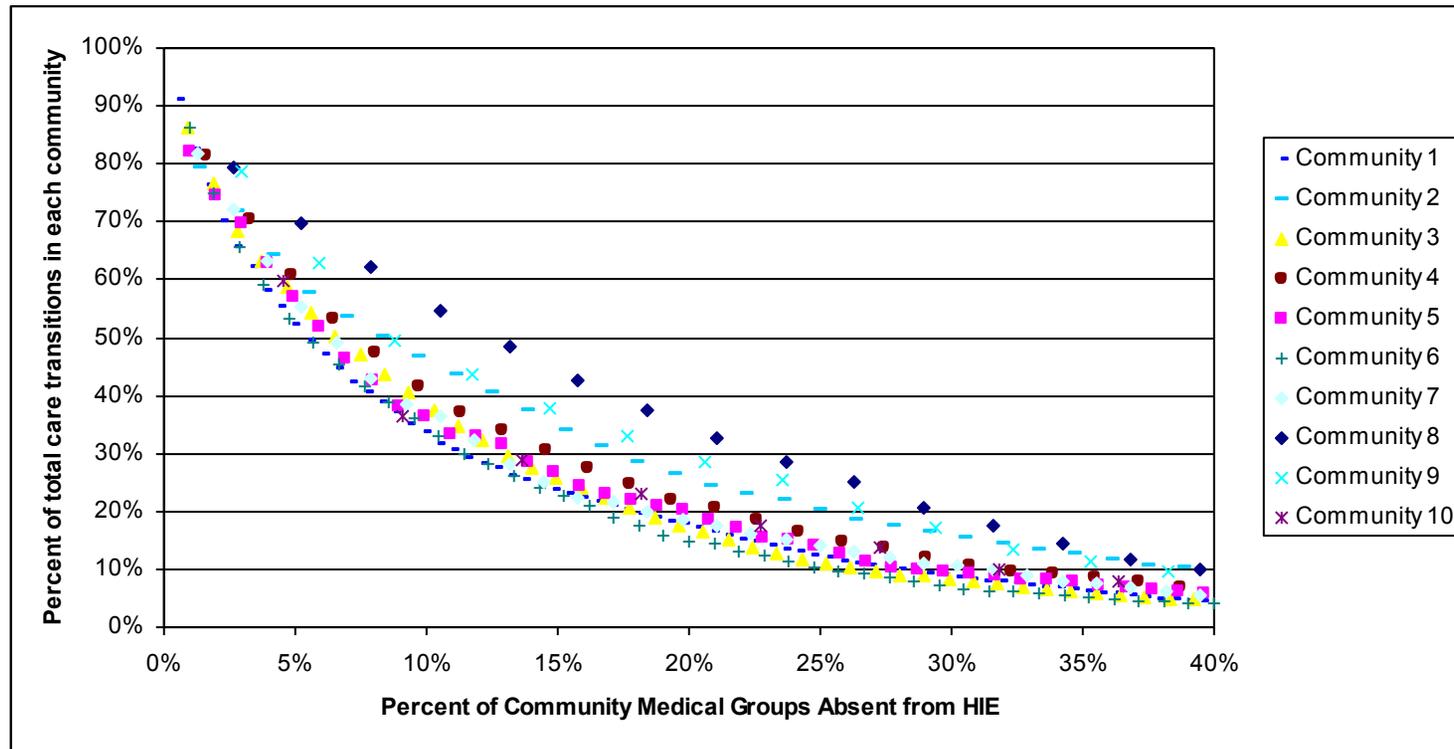


Exhibit 7. Retention (simulation 4, for core specialties only).

Source: Simulation of care transitions in ten Massachusetts communities.

Notes:

This pattern simulates the effect of the absence of medical groups from community HIEs on the potential utility of the HIEs beginning with full participation. The sequence of groups is determined by decreasing volume of care transitions in each community and so the first group has the largest effect. The data include only core specialties and patient visits from January 1st 2005 through June 30th 2006. (Note: The x-axis represents a contrived pattern of variation in medical group mergers, and does not represent time. Every data point simulates all patient visits for the entire the study period.)

Community	No. key groups ¹	Percent of total groups that are key groups ²	Key group descriptions ³	HIE potential utility with key groups only (simulation 3)	Decrease in potential utility of HIE if key groups do not participate (simulation 4) ⁴
1	10	5.49%	Hospital, Multispecialty, Multispecialty, Dermatology, Orthopedic Surgery, Multispecialty, Multispecialty, Primary care & Pediatrics, Hospital, Otolaryngology	19.71%	50.42%
2	7	9.72%	Hospital, Primary care, Multispecialty, Primary care, Cardiovascular Disease, Primary care, Pediatrics	16.63%	53.35%
3	8	7.48%	Hospital, Multispecialty, Multispecialty, Orthopedic surgery, Obstetrics & Gynecology, Pediatrics, Primary care, Orthopedic Surgery	20.16%	53.02%
4	5	8.06%	Hospital, Primary care, Primary care, Ophthalmology, Obstetrics & Gynecology	18.54%	52.51%
5	7	6.93%	Multispecialty, Hospital, Primary care, Hospital, Multispecialty, Primary care, Primary care	17.75%	53.61%
6	6	5.71%	Multispecialty, Hospital, Multispecialty, Multispecialty, Primary care, Orthopedic Surgery	15.11%	51.00%
7	5	6.58%	Hospital, Dermatology, Multispecialty, Orthopedic Surgery, Multispecialty	13.11%	50.81%
8	5	13.16%	Hospital, Primary care & Pediatrics, Primary care, Primary care, Orthopedic Surgery	13.85%	51.70%
9	3	8.82%	Multispecialty, Hospital, Multispecialty	10.67%	50.36%
10	2	9.09%	Multispecialty, Hospital	20.85%	63.52%
median[min- max]	5.5[2-10]	7.77%[5.49%-13.16%]	N/A	17.19%[10.67%- 20.85%]	52.11%[50.36%- 63.52%]

Exhibit 8. Key medical groups (core specialties only, for visits from January 1st 2005 until June 30th 2006).

Source: Simulation of care transitions in ten Massachusetts communities.

Notes:

1. Key groups are those involved in the most care transitions in the community and would limit HIE potential utility to <50% of potential if they did not participate.
2. Total groups are those that constitute 99% of community care transitions.
3. The group descriptions are ordered from those involved in the most community care transitions to the least.
4. Assumes all non-key groups participate in HIE.

Appendix 1: Methodology Details

Designating medical groups

We designated provider numbers in the data set who were listed at the same address as part of the same group. For provider numbers listed at the same address, in a large office building for example, we used the follow steps to designate groups:

1. Put provider numbers which share the same suite number into the same group. (Some providers do not have a suite number.)
2. Of the groups formed in step 1, merge together any groups that have provider numbers with the same listed practice name. (Some providers do not have a listed practice name.)
3. For the remaining provider numbers without listed suite numbers but who do have listed practice names:
 - a. Merge the provider number into an already formed group that has the same listed practice name.
 - b. Put the remaining provider numbers into groups who share the same listed practice name.
4. For the remaining provider numbers without any listed suite or practice name:
 - a. Merge the provider number with the already formed group that has the most provider numbers of their same specialty. (Often there is only one option.)
 - b. Merge the remaining provider numbers with the already formed group that has the most provider numbers in the same specialty category, as defined below
 - c. Form new groups of the remaining provider numbers by grouping specialties according to their same specialty categories.
 - d. For hospital addresses, assign radiologists, pathologists and anesthesiologists to the hospital even if they had another group listed

Specialty categories:

1. Ophthalmology, Optometry
2. Clinical Nurse Specialist, LICSW, Psychiatry, Psychology (Note: Clinical Nurse Specialist is also included in category 6)
3. Dentistry, Endodontics, Periodontics, Oral surgery
4. Anesthesiology, Chiropractic, Neurology, Occupational Therapy, Orthopedics, Physical Therapy Physical Medicine & Rehabilitation, Podiatry
5. Audiology, Otolaryngologist
6. All other core specialties and Dietary Nutritionist
7. All other non-core specialties

Assigning visits to medical groups

All included claims that were listed as occurring in an office-based facility were assigned to the group to which the provider number was assigned as per the method above. Multiple claims ascribed to the same patient and provider number for the same date were considered part of the same visit.

Claims that were listed as occurring in an inpatient facility as well as all emergency claims (as indicated by CPT codes) were considered as part of the same hospital visit if they contained overlapping visit dates. These hospital visits were assigned to a community hospital in our analysis if one or more claim involved with the visit was ascribed to a provider number associated with that hospital. If an inpatient visit did not involve any claim associated with a community hospital, the visit was excluded because the visit may have occurred at a hospital outside of the community. If an inpatient visit involved claims associated with more than one community hospital, the visit was excluded because we were unable to determine at which hospital the visit occurred. To locate the major hospitals in each community, we used Google.

Exclusions

We excluded: all claims assigned to facilities and other claims not labeled “professional”; providers with addresses listed at P.O. boxes; and provider addresses with fewer than 5 claims total in the three 18-month study periods.

We also excluded the following provider specialties:

Ambulatory Surgi-Center	Independent Physiological and
Clinical Lab Participant	Diagnostics Lab
Coordinated Home Health Care	Individual Case Management
Detox facility	Pharmacy (participation)
DME home med equipment/respiratory	Physiological Lab
Free-standing ambulance	Sleep testing facility
Heading Aid Vendor	Surgical day care center
Home health care	Community health center
Home Infusion	

Core specialties

We designated the provider numbers that were listed with the following specialties as “core” and only used claims assigned to those numbers in the portion of our analysis focused on core providers:

Allergy & Immunology	Cardio-thoracic Surgery
Anesthesiology	Certified Nurse Midwife
Anesthetist (certified registered nurse)	Clinical Nurse Specialist
Cardiovascular Disease	Colon & Rectal Surgery

Dermatology
Emergency Medicine
Endocrinology
Family Practice
Gastroenterology
General Practice
General Surgery
Geriatric
Gynecological Oncology
Hand Surgery
Hematology/Oncology
Hospital Based Anesthesiologists
Infectious Diseases
Internal Medicine
IVF
Maternal & Fetal Medicine
Nephrology
Neurology
Neurological Surgery
Neonatal/Perinatal Medicine

Nurse Practitioner
Obstetrics & Gynecology
Ophthalmology
Oral & Maxillofacial Surgery
Orthopedic Surgery
Otolaryngology
Pediatrics and all pediatric sub-specialties
Physician Assistant
Physical Medicine & Rehabilitation
Plastic surgery
Pulmonary Disease
Psychiatry
Psychopharmacology
Reproductive Endocrinology
Rheumatology
Therapeutic Radiology
Urology
Vascular Surgery

Non-core specialties

We designated the provider numbers that were listed with the following specialties as “non-core” and only used claims assigned to those numbers in the portion of our analysis in which we included all providers (core and non-core):

Acute Care Hosp/Diagnostic Imaging
Anatomoc/Clinical Pathology
Audiologist
Chiropractic
Chronic disease hospital
Clinical Psychology
Diagnostic imaging
Diagnostic Radiology
Dietary Nutritionist
Early intervention
Endodontics
General Dentistry
Hematologic Pathology
Hospital Based Pathologists
Hospital Based Radiologists
Hospital (VA)
Hospice
Licensed Mental Health Counselor
LICSW

Multispecialty
Neuropathology
Occupational Therapists
Optometry
Orthodontics
Periodontics
Physical Therapy
Podiatry
Prosthodontics
Radiology
Speech Therapists