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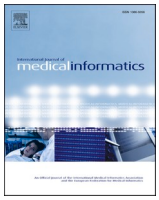

Inter-organizational information sharing and bundled payment reimbursement: Do hospitals in the US use health information exchange to collaborate?

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ABSTRACT

Objective: The purpose of this study is to examine the relationship between the greater need for information generated by bundled payment reimbursement and the use of Health Information Exchange (HIE).
Methods: The study is based on a secondary data analysis using the*American Hospital Association (AHA) Healthcare IT Database* and the *AHA Annual Survey*. A logistic regression was used to test the likelihood of hospitals participating in HIE if they were involved in bundled payment reimbursement. Negative binomial, ordered logistic and Poisson regression models were used to determine the associations between bundled payment reimbursement and health information sharing in terms of breadth, volume, and diversity, respectively.
Results: Hospitals in bundled payment programs were more likely to send and receive information through HIE and to*send* information to different types of health providers but not to *receive*. They were also more likely to exchange different types of health information and to use HIE more often.
Conclusions: The greater need for collaboration of hospitals participating in bundled payment programs was associated with greater information sharing among organizations through HIE, but different providers involved in the episode of care play different roles in HIE.

1. Introduction

Health Information Exchange (HIE) is the electronic sharing of health information among organizations according to nationally defined standards [1–3] and has been a relevant subject of US policymaking since the 2009 Health Information Technology for Economic and Clinical Health Act (HITECH). HIE allows clinical information to securely follow the patient across the health and wellness continuum, enabling disparate health professionals to deliver care in an effective, efficient, and coordinated manner [4]. HIE has the potential to improve the delivery of care by reducing re-admissions, waste, duplicate testing, and medical errors [5] while potentially increasing access to care through disability determination [6]. These potential benefits of HIE are more relevant if one considers the frequency of transitions between health care settings, especially for patients with complex and chronic conditions [4]. However, the traditional fee-for-service reimbursement, which rewards the volume of care, creates no incentive for providers to reduce test duplication or to exchange information with other providers. There is hope that the introduction of bundled payments will motivate greater use of HIE [4].

Bundled payment reimbursement programs represent a paradigm shift from the traditional fee-for-service reimbursement. The US health system is in the early stages of bundled payment reimbursement, with several voluntary initiatives ongoing and the first mandatory test initiated in 2016. With a bundled payment system, providers, who are often disparate, are jointly responsible for the entire episode of care. This places providers in a reimbursement environment with increased complexity and uncertainty. Providers are no longer working in silos and should be availing themselves of information from other care providers along the health care continuum in an attempt to contain costs for each episode of care. An assumption of this paper is that this change in reimbursement scheme increases the need to share information among hospitals and other health care providers, thus potentially increasing the use of HIE.

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2. Background

How organizations react to environmental uncertainty has been examined [7,8]. Research has also examined how and why organizations engage in information sharing [9–11]. However, little research has identified an association between environmental uncertainty and inter-organizational information sharing. One study surveyed a limited number of organizations on environmental uncertainly, information sharing, and supply chain management [12]. Another examines environmental uncertainly generated by alternative payment models (APM) which have incentives and risk for providing high-quality care and information sharing [13]. While some relationships were identified, bundled payments place greater financial pressure on providers than other APMs; in fact, most APMs only have upside rewards for appropriate care, while bundled payments include downside risk penalties, which should result in heightened uncertainty. This review suggests it is critical to examine the role that bundled payments play in fostering information exchange. Constructs considered components of environmental uncertainty include munificence, dynamism, and complexity. Constructs considered components of inter-organizational information sharing include breadth, volume, and diversity.

2.1. Environmental uncertainty

Resource Dependence Theory literature defines uncertainty in the environment based on dynamism, munificence, and complexity [14]. The literature has analyzed these dimensions, frequently focusing on how they are related to organizations' strategy and performance [15].

Dynamism is a change that is hard to predict and heightens uncertainty for key organizational members. [14] A greater perceived dynamism in the environment is related to an increase in uncertainty, which is negatively correlated with the organization's performance measures, such as return on investments and return on assets [15,16].

Munificence is the extent to which the environment can support sustained growth. Its three main characteristics include the abundance of resources, the growth in demand, and the reduced environmental threats. [17] When the environment is not munificent, there is more uncertainty, and an organization's survival may be threatened [18].

Complexity is the heterogeneity of elements in the environment. [19] Complex environments are difficult to analyze. Therefore, organizations need to have deep knowledge and understanding of the environment to pursue business opportunities, leading to lower performance [20]. Translating this to health care and using competition as a measure of complexity, hospitals in areas with a higher competition are less cost-effective than hospitals in areas with lower competition [19]. Findings suggest that greater environmental uncertainty is associated with higher information needs of the organization [21,22].

Bundled payment reimbursement is a shift in health care reimbursement. Providers would need to negotiate how funds are allocated among those delivering care. The outcomes of these negotiations would be hard to predict and would heighten uncertainty, thus increasing *dynamism* in the environment. One assumption about the move to bundled payment reimbursement is that total funds spent on health care services could be reduced over time. Providers that collaborate with others to provide well-coordinated care risk a dramatic reduction in available resources. Thus, there would be a reduction in the *munificence* of the health care environment. Finally, environmental *complexity* would increase with bundled payment reimbursement, since providers would need to develop cooperative arrangements with many different types of providers, including acute and long-term care.

2.2. Inter-organizational information sharing

Inter-organizational information sharing is the sharing of information across organization boundaries [11] aimed at enhancing cooperation and strategic alliances between two or more organizations [23]. The development of information exchanges is not just for short-term transactions; it is part of an ongoing process related to building a trusting relationship between business partners [24]. Exchanging or sharing information with other organizations can lead to cost reductions, productivity improvements, and obtaining or maintaining a competitive advantage in the market [9], but it also raises concerns about security, privacy, and intellectual property [25]. Under environmental uncertainty, organizations are more likely to invest in their relational ties with other organizations [26]. When the exchange of information between organizations happens system-to-system, and in structured, machine-readable form, it is called Electronic Data Interchange (EDI). There are four dimensions of EDI: breadth, volume, diversity, and depth [27–29]. While breadth, volume, and diversity dimensions refer to the information shared, the depth dimension is more related to the technological complexity of the exchange and is not considered in the scope of this paper.

Breadth of information sharing represents the extent to which an organization has established connections with other organizations, usually measured as the number of organizations with which the organization exchanges information [27–29].

Volume of information sharing represents the extent to which an organization's document exchanges are handled electronically, typically measured as the percentage of information exchanged electronically. A higher percentage of electronically shared documents to the total number of documents implies greater technological integration and greater cooperation between organizations [27–29].

Diversity of information sharing represents the number of different types of information shared among organizations. This information can be quite different among organizations in terms of the technology they use and the services they provide. With the volume of information sharing as described earlier, greater diversity of information sharing implies greater technological integration and greater cooperation among organizations [27–29] For the purpose of this paper, cooperation is defined as coordinated actions taken by health care providers in interdependent relationships to achieve mutual goals [27].

HIE is the use of EDI for health care transactions [30,31]. Information sharing and management to coordinate care has been a trend that has characterized health care in many developed countries [32,33] that implemented HIE adoption in diverse ways [34]. In the US, HIE has been found to contribute to improved care coordination and continuity of care, [35,36], and to be an important pillar in building new models of care, such as Accountable Care Organizations [37,38]. As organizations participate in bundled payment initiatives, they will increasingly collaborate to ensure costs and quality associated with care meet targets. Therefore, HIE is expected to grow for non-acute care settings [39] and among health providers [4]. The proposed relationships between the constructs provide the basis for the development of the conceptual framework.

2.3. Conceptual framework

Bundled payment participation may increase environmental uncertainty. The framework in Fig. 1 reveals how environmental uncertainty, defined as participating in bundled payment models, may lead to greater information sharing, identified in the participation in HIE and, specifically, to a greater breadth, volume, and diversity of information shared

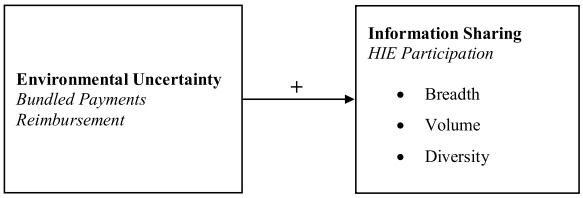


Fig. 1. Conceptual framework for a national perspective on HIE.

among providers.

2.4. Hypotheses

The paper investigates one main hypothesis and three sub-hypotheses.

Hypothesis 1. Participation in HIE: Health providers participating in bundled payment initiatives are more likely to participate in HIE initiatives than those that do not.

Hypothesis 1.1. Breadth of HIE: Health providers participating in bundled payment initiatives exchange information with more types of providers through HIE than those that do not.

Hypothesis 1.2. Volume of HIE: Health providers participating in bundled payment initiatives exchange more information electronically than providers who do not.

Hypothesis 1.3. Diversity of HIE: Health providers participating in bundled payment initiatives exchange more types of clinical information through HIE than providers who do not.

3. Material and methods

3.1. Data collection

Secondary data analysis was used to explore health care IT and payment models. The *American Hospital Association (AHA) Healthcare IT Database* provides information on the depth and level of technology integration within hospitals. It contains information on health care IT, including HIE functionality, for more than 3300 hospitals. HIE functionality was determined with information relative to whether the organization exchanges information, how routinely it electronically exchanges clinical information from outside sources, with what kind of organizations (including different types of care settings and whether the other organization is inside or outside the system in which the organization belongs), and what kind of information. The *AHA Healthcare IT Dataset* is considered a reliable and valid measure of hospitals' use of information technology [40].

To investigate bundled payment participation, the AHA Annual Survey Database is also used. Responses to the following question were included: "*Does your hospital participate in a bundled payment program involving inpatient, physician, and/or post-acute care services where the hospital receives a single payment from a payor for a package of services and then distributes payments to participating providers of care (such as a single fee for hospital and physician services for a specific procedure, e.g., hip replacement, CABG)?*" At the time of this study, this question field appeared in the dataset only for Fiscal Year 2015; therefore, the same fiscal year was used for the AHA IT Supplement.

3.2. Operationalization

This study looks at four different hypotheses with four different dependent variables in HIE: participation, breadth, volume, and diversity.

Participation in HIE. The general hypothesis (H1) is that participating in bundled payments initiatives will be associated with greater use of HIE. Participation in HIE is measured by *HIE participation*, which is a dichotomous variable (yes/no) in the AHA IT dataset on the active participation in HIE. The AHA IT dataset measures five main ways to exchange information: mail or fax, eFax using EHR (Electronic Health Record), secure messaging using EHR (via DIRECT or other secure protocol), provider portal (i.e., post to portal or download from portal), and via HIE organization or other third party.

Breadth of information sharing. The first sub-hypothesis (H1.1) states that breadth of information sharing will increase with the introduction of bundled payments because of an increase in the exchange of information between acute care and post-acute care providers. Breadth of information sharing represents the extent to which an organization has established connections with other organizations. From the available data, it is not possible to know the exact number of providers with which the hospital exchanges information; however, a proxy to measure breadth of information sharing in the case of HIE can be obtained by creating a summated scale variable based on the different types of providers with whom the organization exchanges information. The dichotomous variables (yes/no) that compose the summated scale are: other hospitals outside the system, ambulatory care providers outside the system, long-term care providers (inside or outside the system), and behavioral health providers (inside or outside the system). The AHA IT Supplement dataset reports information about whether each hospital sends and/or receives information from each of the identified types of providers. Therefore, two summated scale variables, *HIE breadth send* and *HIE breadth receive*, are created as count variables with values from 0 (no types of providers) to 4 (all four types of providers).

Volume of information sharing. The benefits of HIE are proportionate to the volume of information exchanged [41]. Volume of information sharing represents the extent to which organizations' document exchanges are handled electronically. In the second sub-hypothesis (H1.2), it was stated that hospitals will exchange a greater percentage of information electronically to obtain the maximum benefit from the exchange. From the available dataset, it is not possible to establish the exact percentage of information shared electronically. However, a proxy of the volume of information sharing can be obtained by looking at the frequency of HIE use. Specifically, the AHA IT Supplement reports how frequently providers at each hospital use patient health information received electronically from outside providers or sources when treating a patient. The frequency reported consists in four main categories: often, sometimes, rarely, and never. Therefore, the count variable *HIE volume* is created taking values from 0 (never) to 3 (often).

Diversity of information sharing. The third sub-hypothesis (H1.3) posits that diversity of information sharing will increase because of the introduction of bundled payment reimbursement. It is thought that the reimbursement structure that cuts across the entire continuum of care will motivate providers to exchange detailed information about the patient's health condition to meet the target of the bundled payment. Diversity of information sharing represents the number of different types of information the organization shares. To measure the different types of documents shared, a summated scale variable is created, composed by the following dichotomous (yes/no) variables: patient demographics, laboratory results, medication history, radiology reports, and clinical/summary care record in any format. Therefore, *HIE diversity* is a count variable that can take values from 0 (no types of information) to 5 (all five types of information).

The main independent variable of this paper is the participation in bundled payment initiatives.

Participation in bundled payments. The main independent variable is a dichotomous variable representing the participation in bundled payments. The variable *bundled payment participation* can take values 0 (not participating) or 1 (participating).

Control variables. Some organizational characteristics are used as control variables to obtain a better estimation of how participating in bundled payments affect HIE, devoid of the specific hospital characteristics. Based on prior research in health care management and technological innovation, [42] some organizational variables were included as control variables, including geographical location, network participation, bed size, and ownership.

3.3. Method of analysis

The datasets were merged using the AHA Identification Number, and the analyses performed using Stata 16. Logistic regression was used to test to the likelihood of hospitals participating in HIE if they were involved in bundled payment initiatives. Ordered logistic regression was

used to analyze the impact of participating in bundled payments on volume of information exchange. To determine the increase in health information sharing in terms of breadth and diversity, Negative Binomial and Poisson regression models were used, since proxies for breadth and diversity of information sharing and those proxies are counts (*HIE breadth* and *HIE diversity*). Specifically, after testing for overdispersion, the breadth of HIE, both for sending and receiving information, showed a significant overdispersion, while diversity of HIE did not show a significant overdispersion; therefore, two negative binomial model were used for *HIE breadth*, and a Poisson model was used for *HIE diversity*.

4. Results

The sample includes 3510 hospitals. Descriptive statistics for the organizational characteristics, presented in Table 1, and for the extent of HIE participation, presented in Table 2, exhibit wide variation in most instances. A further examination of the sample was performed, focusing on how organizational characteristics differ between hospitals that participate in bundled payment programs and those that do not participate). From this further analysis, it emerges how hospitals in bundled payment programs tend to be in metropolitan areas (91 % of the hospitals in Bundled Payment programs), have a large size (47 %), and be in a network (59 %) (Appendix A).

From the regression models, it emerged that some organizational characteristics were associated with all the aspects of the HIE part of this analysis. In particular, hospitals that are part of a network, compared to those that are not, were more likely to send and receive information through HIE, to send and receive information to and from a higher number of providers, to exchange information often, and to exchange more types of information (all coefficient significant, $p < 0.01$). The same trend can be observed for not-for-profit hospitals, compared to government-owned hospitals. On the other hand, for-profit hospitals were found to be less likely to send and receive information to and from a higher number of providers, and to exchange more types of information. The other organizational characteristics showed a significant effect on some of the dependent variables.

Hypothesis 1. Participation in HIE

Table 3 shows the results of the logistic regression investigating the relationship between participating in bundled payment programs and the likelihood of using HIE to send and receive information to and from other providers. The model was statistically significant (Prob > chi2 = .000).

Table 1
Descriptive statistics: organizational characteristics.

	No.	%
Bed size		
Small (<100 beds)	1733	49.4
Medium (100–299 beds)	1133	32.3
Large (≥ 300 beds)	644	18.3
Total	3510	100
CBSA Type		
Metro	2332	66.4
Micro	533	15.2
Rural	645	18.4
Total	3510	100
Ownership		
Government	812	23.1
Not-for-profit	2000	57
For Profit	698	19.9
Total	3510	100
Network		
No	1741	58
Yes	1260	42
Total	3001	100

Table 2
Descriptive statistics: HIE and Bundled Payments.

	No.	%
Send Health Information through HIE		
No	1597	45.5
Yes	1913	54.5
Total	3510	100
Receive Health Information through HIE		
No	2029	57.8
Yes	1481	42.2
Total	3510	100
Breadth of HIE (number of types of provider in HIE)—Send		
0	1260	35.9
1	367	10.5
2	479	13.6
3	497	14.2
4	907	25.8
Total	3510	100
Breadth of HIE (number of types of provider in HIE)—Receive		
0	2046	58.3
1	268	7.6
2	391	11.1
3	272	7.7
4	533	15.2
Total	3510	100
Volume of HIE (Frequency of HIE)		
Never	615	20.5
Rarely	645	21.5
Sometimes	1067	35.6
Often	668	22.3
Total	2995	100
Diversity of HIE (number of types of information exchanged)		
0	957	27.3
1	195	5.6
2	170	4.8
3	346	9.9
4	1842	52.5
Total	3510	100
Bundled Payment Program		
No	2400	83.6
Yes	471	16.4
Total	2871	100

Table 3
Bundled payment participation and use of HIE.

	Send Health Information through HIE	Receive Health Information through HIE
Bundled Payment Program	1.343	1.259
	(2.46)**	(2.06)**
Large	1.482	1.322
	(3.24)***	(2.47)**
Small	0.796	0.825
	(2.34)**	(1.96)**
Metropolitan Area	1.441	1.368
	(3.00)***	(2.50)**
Micropolitan Area	1.317	0.919
	(2.00)**	(0.59)
Not-for-Profit	2.198	1.900
	(7.89)***	(6.19)***
For Profit	0.886	1.046
	(0.90)	(0.32)
Network	1.331	1.284
	(3.46)***	(3.08)***
N	2855	2855

OR Coefficients. Standard errors in parentheses.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

Hospitals participating in bundled payment programs were six percentage points* more likely to send information through HIE (OR = 1.324, $p < 0.05$). Compared to average-size hospitals in this sample, small hospitals were less likely to send information through HIE, while large ones were more likely to send information. Hospitals in both metropolitan and micropolitan statistical areas were more likely to send information than hospitals in rural areas.

Hospitals in bundled payment programs were also more likely to receive information through HIE (OR = 1.259, $p < 0.05$). Compared to average-size hospitals in this sample, small hospitals were less likely to receive information through HIE, while large ones were more likely to receive information. Hospitals in metropolitan statistical areas were more likely to receive information through HIE than hospitals in rural areas.

Hypothesis 1.1. Breadth of HIE

The first two columns of Table 4 show results of the Negative Binomial regression, investigating the relationship between hospital participation in bundled payment programs and the number of different types of providers to whom information was sent and from whom information was received. The model was statistically significant (Prob > chi2 = .000). While the number of types of providers to whom information was sent was 13 % higher (2.16 vs. 1.90†) for hospitals that participate in bundled payment programs as compared to those that do not, there was no significant difference in the number of types of providers from whom those hospitals received information. Large hospitals sent information to more types of providers than average-size hospitals, while small hospitals only had 85 % of the breadth of types of providers to whom information was sent as compared to average-size hospitals.

Compared to rural hospitals, hospitals in metropolitan areas sent information through HIE to 11 % more types of providers. Similarly, hospitals in micropolitan areas sent information through HIE to 20 % more different types of providers.

Hypotheses 1.2. Volume HIE

The third column of Table 4 exhibits the results of the ordered logistic regression investigating the relationship between hospitals' participation in bundled payment programs and volume of HIE. When looking at the volume rating (0–4 expressing the frequency of HIE use), keeping everything else constant, hospitals in bundled payment programs were more likely to have a higher volume of HIE. In particular, looking at the marginal effects,‡ on average, hospitals in bundled payment reimbursement schemes are 3.58 percentage points less likely to state that they never exchange information with other providers, and about 3.97 percentage points more likely to state that they often exchange information with other providers (Appendix D). Large hospitals were more likely to have a higher volume rating compared to average-size hospitals. The volume rating for hospitals in micropolitan areas was found higher than rural hospitals, but no significant association was found between metropolitan hospitals and HIE.

Hypothesis 1.3. Diversity of HIE

The last column of Table 4 exhibits the results of the Poisson regression investigating the relationship between hospitals' participation in bundled payment programs and diversity of HIE. Keeping everything else constant, the diversity of HIE was 6% higher (2.75 vs. 2.60 types of information§) for hospitals that participate in bundled payment programs compared to those that do not participate in bundled payment programs. Large hospitals exchange 8% more different types of information than average-size hospitals, while small hospitals only had 84 % of the diversity of information sharing of average-size hospitals. Compared to rural hospitals, hospitals in micropolitan areas exchange 16 % more different types of information ($p < 0.01$), while no statistically significant difference was found between metropolitan and rural hospitals.

Table 4
Bundled payment participation and breadth, volume and diversity of HIE.

	Breadth of HIE—Send.	Breadth of HIE—Receive.	Volume of HIE.	Diversity of HIE
Bundled Payment Program	1.134	1.078	1.265	1.059
	(3.60)***	(1.27)	(2.29)**	(1.80)*
Large	1.085	1.102	1.265	1.078
	(2.33)**	(1.60)	(2.31)**	(2.37)**
Small	0.852	0.907	0.991	0.838
	(4.00)***	(1.49)	−0.1	(5.94)***
Metropolitan Area	1.113	1.335	1.699	1.053
	(1.96)*	(3.41)***	(4.53)***	−1.33
Micropolitan Area	1.207	1.281	1.17	1.155
	(3.22)***	(2.64)***	−1.22	(3.37)***
Not-for-Profit	1.291	1.525	1.709	1.256
	(5.96)***	(6.17)***	(5.70)***	(7.31)***
For Profit	0.489	0.473	0.849	0.774
	(8.31)***	(5.67)***	−1.15	(5.55)***
Network	1.144	1.210	1.206	1.050
	(4.48)***	(3.91)***	(2.50)**	(2.05)**
cut1			0.55	
			(4.31)***	
cut2			1.646	
			(3.62)***	
cut3			8.636	
			(15.03)***	
N	2855	2855	2432	2855

IRR Coefficients for Breadth and Diversity. OR Coefficients for Volume. Standard errors in parentheses.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

5. Discussion

Returning to the hypotheses, the results suggest:

H1. Participation in HIE: Health providers participating in bundled payment initiatives are more likely to participate in HIE initiatives than those that do not.

Health care providers participating in bundled payment initiatives seem to be more likely (6 percentage points) to engage in HIE activities than those providers that did not participate. Participation with bundled payment initiatives was also associated with the exchange of information through HIE with more types of providers than those that were not involved in bundled payments. The finding that hospitals in bundled payment programs seem more likely to use HIE seems to support the idea of a greater need for collaboration when participating in episode-based reimbursement [43] and the consequent increased use of HIE [4].

H1.1. Breadth of HIE: Health providers participating in bundled payment initiatives exchange information with more types of providers through HIE than those that do not.

There was a statistical significance in the number of types of providers to whom information was sent; however, that same significance did not translate to the number of types of providers from whom information was received.

* Margins plot in the appendix B.
† Margins plot in Appendix C.
‡ Marginal effects and margins plot in appendix D.
§ Margins plot in appendix E.

An interesting finding is that being in a bundled payment program was associated with a higher likelihood of *sending* information to different types of health providers but not of *receiving* information from several types of health providers. A possible explanation could be that hospitals are often the provider where the patient has the first encounter and, therefore, the hospital bears the financial risk for all the other providers [44]. Being the provider in charge of the episode may actually put hospitals in the position to be incentivized to share information, while the other providers involved in the episode could perceive less pressure to share. Another explanation could be that hospitals have made larger investments in information systems than other types of providers and that they also have more protocols for sharing information. Moreover, a recent article discussed how there is still an uneven presence of HIE across the US; [45] therefore, HIE might not be as widespread in some states as in others, and only a few large health systems might have access to it. This seems to be confirmed by another recent study on organizational perspectives on HIE analyzed why the information received through HIE was not used, and a main reason was that other organizations in the area do not use HIE [46].

H1.2. Volume of HIE: Health providers participating in bundled payment initiatives exchange more information electronically than providers who do not.

Providers participating in bundled payment initiatives seem to exchange more often through HIE than providers who do not participate in those payment initiatives. This is in net contrast with what has been found in previous research about participation in APMs and HIE. In particular, previous research has found participation in APMs to be associated with a lower volume of HIE [13]. A possible explanation of this difference might be that most APMs focus on upside rewards for appropriate care, while bundled payments include downside risk penalties, which puts the hospital under a greater financial pressure to exchange information as routinely as possible. Another explanation could be that, while partners in many APMs are specifically set (such as participating in ACOs or PCHMs), the providers involved in bundled payment might be different for each episode of care, leading the hospital to increase their general volume of HIE, instead of focusing on a few partner-specific connections.

H1.3. Diversity of HIE: Health providers participating in bundled payment initiatives exchange more types of clinical information through HIE than providers who do not.

Hospitals in bundled payment programs also seem to be more likely to exchange different types of health information. A possible explanation can be found in the different technological capabilities between hospitals and other types of health providers (long-term care, ambulatory) and also in the fact that hospitals may decide to share only certain information that they consider important for the care of the patient.

Some limitations are evident. First, due to data availability, this is a cross-sectional study, meaning that all the observations are obtained at a single point in time. Cross-sectional regressions have limitations in terms of possible endogeneity, omitted variable bias, model uncertainty, and measurement error. Therefore, we cannot infer causality between participating in bundled payment programs and the use of HIE, and we can only state that there is an association and suggest that this is illustrative of early efforts of a use case for HIE. Another limitation relates to the way the data were collected in the AHA IT Supplement. Starting from 2015, AHA took out the zeros from the datasets, because it was a default. The questions asked to "check all that apply." In the past, if any of the items in that question were checked, the unchecked items defaulted to zero. But as of 2015, researchers are unable to distinguish a missing answer from a zero answer among the items that remained unchecked. Therefore, results may be inflated for possible missing values interpreted as negative responses. Furthermore, the data did not provide detail on the type of bundled payment program the hospital participated in and on the other organizations involved in it. Finally, the level of uncertainty may depend on the extent of bundled payment participation. If the provider's participation in bundled reimbursement initiatives is small, the level of uncertainty may be lower due to less revenues at risk. Also, even if the hospital is not participating in bundled payments yet, it may still perceive environmental uncertainty if it is planning to apply for bundled payment reimbursement soon. Unfortunately, the data available for this study does not provide insights about the extent or the future planning for bundled payment participation.

5.1. Implications of findings

This research has implications for policy, management, and future research. From a policy perspective, the association between bundled payment participation and HIE use suggests that reimbursement models that require collaboration, for instance, episode-based reimbursement, could play a role in increasing the use of HIE by health providers and may illustrate a use case for HIE. This supports findings of prior research which examined a more diverse array of APM [13]. From a management perspective, these findings suggest that information technology, and specifically HIE, can be an essential tool to ensure better cooperation with other providers in an episode of care and assist providers in controlling the level of resources used for the episode, as has been found in specific health system settings [47].

Finally, this paper identified a statistically significant association between participation in bundled payment programs and the use of HIE. However, further research is needed to investigate elements that can affect or moderate this relationship. Future research could investigate in more detail when observing the variables of breadth, volume, and diversity of HIE, using clinical experts' groups to redefine these items in a more weighted manner instead of using general summated scales for each item.

6. Conclusions

This paper analyzed how environmental uncertainty affects inter-organizational information sharing, discussing the particular case of the health care sector and, specifically, the sharing of information among hospitals in bundled payment programs. The identified conceptual framework depicted a relationship between the environmental uncertainty generated by the introduction of bundled payments reimbursement and inter-organizational information sharing measured in terms of breadth, volume, and diversity of information sharing. The hypotheses developed were tested and were generally confirmed, suggesting that greater environmental uncertainty is associated with greater information sharing among organizations in the industry.

CRediT authorship contribution statement

Claudia Guerrazzi Young: Conceptualization, Methodology, Data curation, Formal analysis, Writing - original draft. **Sue S. Feldman:** Supervision, Writing - review & editing. **S. Robert Hernandez:** Supervision, Writing - review & editing.

Declaration of Competing Interest

The authors report no declarations of interest.

Summary points

What is already known:

- HIE has the potential to improve the delivery of care by reducing re-admissions, waste, duplicate testing, and medical errors, while potentially increasing access to care through disability determination.
- The traditional fee-for-service reimbursement, which rewards the volume of care, creates no incentive for providers to reduce test duplication or to exchange information with other providers. APMs were found associated with HIE.

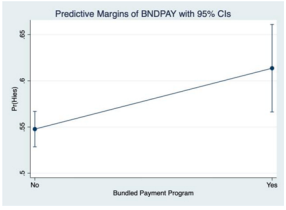
What this study has added:

- There is an association between bundled payment participation and HIE use, which suggests that episode-based reimbursement models could play a role in increasing the use of HIE by health providers.
- Hospitals involved in bundled payments seem more likely to *send* information to different types of health providers but not to *receive*, which highlights a diversity in the role played in HIE by the different providers involved in the episode of care.
- Hospitals involved in bundled payments seem also more likely to use HIE more often, suggesting that participating in bundled payment reimbursement models might affect volume positively, while other APMs might not.

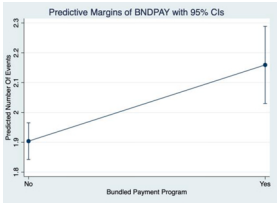
Appendix A. Descriptive statistics by Bundled payment program participation

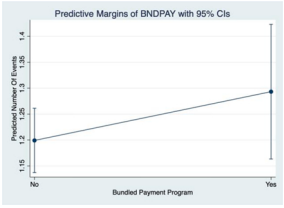
		Bundled Payment Program					Bundled Payment Program		
CBSA TYPE		No	Yes	Total	CBSA TYPE		No	Yes	Total
	Metropolitan	1481	428	1909		Metropolitan	62 %	91 %	66 %
	Micropolitan	414	23	437		Micropolitan	17 %	5%	15 %
	Rural	505	20	525		Rural	21 %	4%	18 %
	Total	2400	471	2871		Total	100 %	100 %	100 %
Bed Size					Bed Size				
	Small	1276	84	1360		Small	53 %	18 %	47 %
	Medium	774	164	938		Medium	32 %	35 %	33 %
	Large	350	223	573		Large	15 %	47 %	20 %
	Total	2400	471	2871		Total	100 %	100 %	100 %
Ownership					Ownership				
	Government	577	57	634		Government	24 %	12 %	22 %
	Not-for-profit	1422	360	1782		Not-for-profit	59 %	76 %	62 %
	For Profit	401	54	455		For Profit	17 %	11 %	16 %
	Total	2400	471	2871		Total	100 %	100 %	100 %
Network					Network				
	No	1443	191	1634		No	60 %	41 %	57 %
	Yes	946	275	1221		Yes	40 %	59 %	43 %
	Total	2389	466	2855		Total	100 %	100 %	100 %

Appendix B. Margins plot for the effect of Bundled Payment on the probability of sending information through HIE



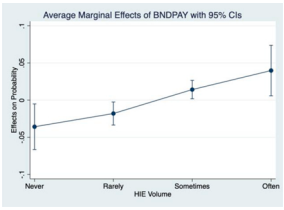
Appendix C. Margins plot for the effect of Bundled Payment on the number of types providers the hospitals send to (left) and receive from (right) information



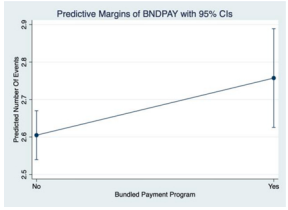


Appendix D. Marginal effects of Bundled payment participation on volume of HIE and margins plot

		Delta-method				
	dy/dx	Std. Err.	z	P > z	[95 % Conf.	Interval]
BNDPAY						
_predict						
Never	−0.0358436	0.0156548	−2.29	0.022	−0.0665264	−0.0051609
Rarely	−0.018067	0.0079098	−2.28	0.022	−0.0335699	−0.002564
Sometimes	0.0141486	0.0062986	2.25	0.025	0.0018036	0.0264936
Often	0.039762	0.0173222	2.3	0.022	0.0058111	0.073713



Appendix E. Margins plot for the effect of Bundled Payment on the number of types of information the hospital exchanges



Appendix F. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ijmedinf.2020.104298.

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