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Hospital-centered violence intervention programs: a cost-effectiveness analysis

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Abstract

BACKGROUND: Hospital-centered violence intervention programs (HVIPs) reduce violent injury recidivism. However, dedicated cost analyses of such programs have not yet been published. We hypothesized that the HVIP at our urban trauma center is a cost-effective means for reducing violent injury recidivism.

METHODS: We conducted a cost-utility analysis using a state-transition (Markov) decision model, comparing participation in our HVIP with standard risk reduction for patients injured because of firearm violence. Model inputs were derived from our trauma registry and published literature.

RESULTS: The 1-year recidivism rate for participants in our HVIP was 2.5%, compared with 4% for those receiving standard risk reduction resources. Total per-person costs of each violence prevention arm were similar: $3,574 for our HVIP and $3,515 for standard referrals. The incremental cost effectiveness ratio for our HVIP was $2,941.

CONCLUSION: Our HVIP is a cost-effective means of preventing recurrent episodes of violent injury in patients hurt by firearms.

First discussed in the surgical literature 3 decades ago, injury recidivism because of interpersonal violence is an ongoing problem for our nation's urban trauma centers and the communities they serve.[1–3] In response to this major public health issue, trauma centers and community organizations have collaborated to develop hospital-centered tertiary violence prevention programs aimed at reducing the incidence and burden of recurrent violent injury.[4] Evaluations of these violence intervention programs demonstrate that they are effective in reducing both violent injury recidivism[5] and criminal justice recidivism.[6] Accordingly, the widespread success of these programs has led to the development of the National Network of Hospital-Based Violence Intervention Programs,[7] the aim of which is to promote best practices, create evidence-based research, and affect policy change.

Although most evaluations on hospital-centered violence intervention programs (HVIP) have concentrated on clinical outcomes, there is also a need to include costs into program assessment. This will allow for a better

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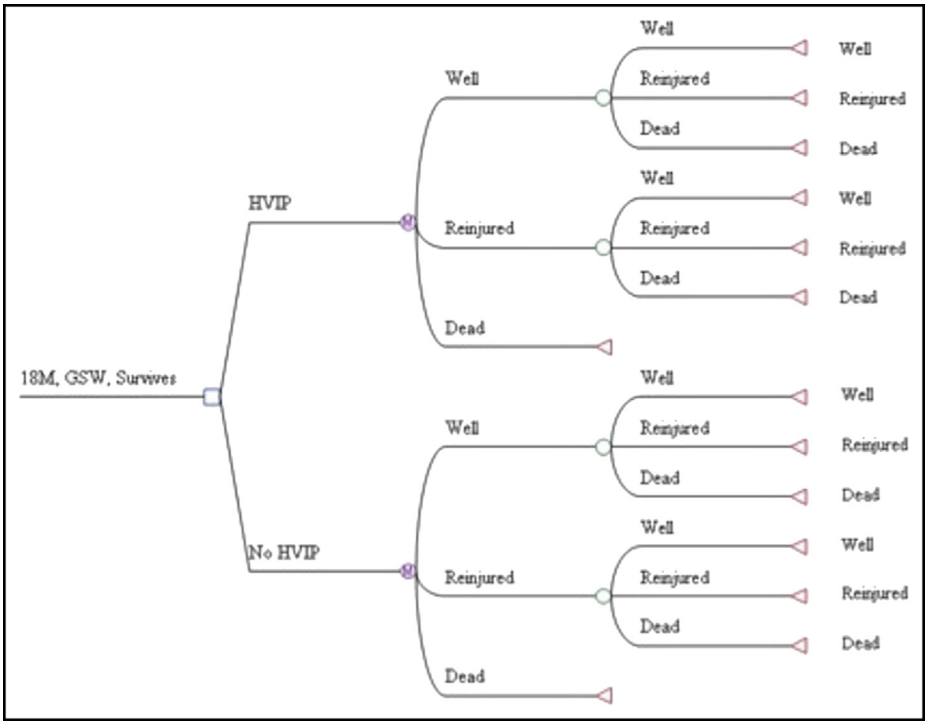

Figure 1 The first branch in our tree is a decision node leading to either participation in our HVIP or receipt of standard risk reduction services (no HVIP). Patients in each arm then enter a Markovian state-transition model, in which they cycle through 3 different health states yearly: well, reinjured, and dead. 18M, GSW = 18-year-old patient with a gunshot wound.

understanding of the value of such programs in comparison with standard risk reduction strategies utilized in trauma centers and emergency departments. Early evidence on the cost savings of hospital-based violence intervention programs has been indirect, but promising.[8] For example, an evaluation of the hospital-based violence intervention program at the R Adams Cowley Shock Trauma Center in Baltimore, MD, demonstrated a recidivism rate for program participants of 5% compared with 36% for a control group that did not receive any violence intervention services.[5] This corresponded to a cost difference of $598,000 between groups in regards to their recidivism hospitalization costs. Similarly, a non-peer reviewed analysis of 32 participants from Project Ujima in Milwaukee, WI, found that violence intervention program to be a cost-effective program at a willingness-to-pay threshold of $1,466.[7] Moreover, by reducing subsequent involvement of program participants in the criminal justice system, hospital-based violence intervention programs have also produced cost savings from a societal perspective in the estimated range of $750,000 to $1 million annually.[5,6]

To build on the efforts of previous evaluations, the aim of this article is to conduct a dedicated cost analysis of our trauma center's HVIP using standard cost-effectiveness methods.[9] This study compares participation in such a program with receipt of standard risk reduction resources for patients injured by firearm violence, and we hypothesized that our violence intervention program is a cost-effective means of reducing recurrent violent injury.

Patients and Methods

Study design

This is a cost-effectiveness analysis from a healthcare perspective. A state-transition Markov decision tree was constructed using decision software (TreeAge Pro Healthcare Module 2011; TreeAge Software, Inc, Williamstown, MA) to model the probability of recurrent violent injury with or without violence intervention services (Fig. 1). Our model compared 2 violence prevention strategies available to our patients after discharge: (1) participation in an HVIP consisting of intensive case management services or (2) receipt of standard counseling and referrals from emergency department and trauma social workers with no scheduled or routine follow-up. Patients in each treatment arm are then cycled through one of 3 health states: well (meaning no episodes of violent reinjury), recurrent violent injury, and death.

Interventions

Since 1994, our hospital (Highland Hospital) in Oakland, CA, has collaborated with Youth ALIVE!, a community organization dedicated to violence prevention and youth leadership development, to provide services to victims of interpersonal violence seen at our trauma center. This violence intervention program, called Caught in the

Crossfire, aims to reduce retaliatory violence, subsequent violent reinjury, and involvement in the criminal justice system. Violently injured patients treated in our emergency department are initially seen by our injury prevention coordinator, by whom they are screened to determine their eligibility for our violence intervention program. If the patient is eligible and agrees to proceed, they are then met by an intervention specialist from Caught in the Crossfire, ideally while still in the hospital, but sometimes after discharge. If the patient is ineligible or declines to participate in the program, they receive standard risk reduction services in the form of counseling by the injury prevention coordinator, but they do not receive any scheduled or routine follow-up.

Participation in our violence intervention program includes an initial assessment of the client's needs, as well as those of their family. The client then receives intensive case management services designed to meet these needs, including help obtaining state victim-of-violence restitution funds, assistance with insurance enrollment and medical costs, transportation to and from medical appointments or court hearings, help with obtaining education or employment needs, driver's licenses, and referrals to mental health counseling.

Base case

Our base case is an 18-year-old patient who presents to our trauma center with a firearm injury because of interpersonal violence and survives to hospital discharge. As our decision analysis is based on the probability of recurrent violent injury, patients who die in the hospital after their index injury are excluded from our defined population. Those patients who present with nonpenetrating mechanisms of interpersonal violence were also excluded, as they are unlikely to enroll in our hospital-affiliated violence intervention program after their index injury.

Probabilities

Probabilities of clinical outcomes were derived both from our trauma center's experience and the published literature (Table 1). Yearly violent injury recidivism rates used in the base case analysis were calculated from our trauma registry data in the following manner. Patients aged 12 to 20 years presenting with a firearm injury because of interpersonal violence from 2005 to 2008 were identified as our sample population. This age range was chosen based on the eligibility criteria for participation in our HVIP. Patients with self-inflicted firearm injuries, who were shot by law enforcement, or who died prior to discharge were excluded from our analysis. By cross-referencing client records from our HVIP, we divided our sample population into 2 groups: (1) those who participated in the violence intervention program and (2) those who did not. Participation in the violence intervention program was defined as having 3 or more contacts in the first month after violent injury, with at least one contact being in person. Each patient in both groups was then followed out to a year after their index injury to identify any repeat episodes of violent injury. The proportion of patients in each group that had recurrent episodes of violent injury was used as the annual probability of violent injury recidivism in our decision tree.

To conduct sensitivity analyses, a range of annual probabilities for violent injury recidivism was obtained from the published literature (Table 1). When multiple-year injury recidivism rates were published, these were divided by the range of years included to obtain an annual rate. For example, a 5-year recidivism rate from the literature was divided by 5 to create an annual rate.

Costs

Hospital costs used in our decision tree were derived from our trauma center's experience (Table 1). Charges for each of our patients' hospital stays were captured in our trauma registry. Hospital charges for episodes of recurrent violent injury were determined for each treatment arm, and these were converted to costs using annual Medicare cost-to-charge ratios for urban hospitals in California, available via the Centers for Medicare & Medicaid Services website.[9] All costs were then standardized to US 2010 dollars using the appropriate price indices obtained from the United States Bureau of Labor Statistics website. Average costs were inputted into our base case analysis, and cost ranges were used in our sensitivity analysis. To

Table 1 Decision tree variable inputs

	VIP		Standard referrals	
Variable	Base case	Range	Base case	Range
Annual recidivism	2.5%	0%–5%[5,10–12]	4%	0%–11%[1–3,5,11,13–20]
Hospital costs after recidivism	$6,513 (avg)	$1,996–$100,000	$18,722 (avg)	$1,601–248,536
Cost of VIP	$2,810		N/A	

Model inputs for the base case were derived from our trauma registry data. Ranges for the sensitivity analyses included data from our trauma registry, as well as the published literature.

avg = average; N/A = not applicable; VIP = violence intervention program.

broaden our range of recidivism hospitalization costs, we included recidivist events up to 5 years from the index case. Ranges for our sensitivity analysis also included estimates of hospitalization costs from the published literature.[5,7,21]

Per person costs for participating in our hospital-affiliated violence intervention program were calculated by dividing the annual operating budget of the program by the number of clients served.

Utilities

Utility values were obtained using data from a previously published cost analysis of trauma center care and the National Study on Costs and Outcomes of Trauma.[22] Accordingly, patients surviving through the first year after their index injury were assigned a utility value of .7 for that year. Subsequent transition to health states of well or death correlated with an assigned utility of 1.0 and 0, respectively. In our Markov model, any time a patient was reinjured because of interpersonal violence, they were reassigned a health utility of .7 for that year.

Analysis

A 1-year cycle time frame was used to capture the index injury and any subsequent episodes of violent reinjury requiring evaluation at our trauma center. The analytic horizon included 5 years after the index injury, translating to 5 Markovian cycles in our model.

Univariate and bivariate sensitivity analysis was performed on key variables to explore possible alternatives to the base case model conclusion. The results of the model were said to be sensitive to any particular variable if the recommendation changed for the corresponding range of individual variables.

Assumptions

Several assumptions were made in the construction of our decision model to simplify the analysis. First, in each treatment arm, all patients had an equal yearly chance of violent injury recidivism regardless of their discharge status. Second, yearly chances of recidivism were stable throughout the analytic horizon and did not change based on previous episodes of recidivism. In other words, although previous research has suggested that the chances of recidivism are higher if you have previously had a recidivist event,[13] this complexity was too difficult to capture in our decision tree with the data available to us. Third, we assumed that victims of violent injury who survived to 1 year after discharge and remained uninjured returned to a normal health state represented by a health utility of 1.0, although in reality, depending on the severity of their index injury, patients experience a wide range of postinjury health states.

Results

During the study period, our trauma center treated 3,830 incidents of interpersonal violence. Of these, there were 511 index cases that met our inclusion criteria (age, mechanism, and survival to discharge). Our HVIP successfully enrolled 31% of these index patients (n = 155).

Demographic and clinical comparison between clients of our violence intervention program and patients receiving only standard risk reduction services can be seen in Table 2. The only demographic difference between the 2 groups emerged from the insurance data; clients of our violence intervention program were more likely to have public insurance and less likely to be uninsured when compared with the group of patients who did not enroll in the program. Otherwise, age, sex, and race proportions were similar for the 2 groups. Clinically, clients of Caught in the Crossfire presented with higher injury severity scores at the index case. However, other measures of trauma severity, such as revised trauma score, motor portion of the Glasgow coma score, and presenting systolic blood pressure, were similar between groups. Finally, clients of Caught in the Crossfire were more likely to be admitted after their index case, to have an emergency operation, and to be in the hospital for a longer stay than their nonparticipant counterparts.

In regards to recidivism, 4 patients (2.5%) who participated in our violence intervention program had a recidivist event within 1 year of their index case. In contrast, 14 patients (4%) who received only standard risk reduction services through the emergency department had a recidivist event within 1 year of their index case. This difference was not statistically significant.

Base case

In the 5-year time frame of this decision analysis, the total per-person cost of our HVIP was $3,574, and this was associated with an effectiveness of 4.64 quality-adjusted life years (QALYs). In contrast, the nonintervention arm of this model bore a cost of $3,015 with an effectiveness of 4.62 QALYs. The incremental cost of our violence intervention program was $59, resulting in an incremental cost effectiveness ratio of $2,941/QALY.

Sensitivity analysis

Univariate sensitivity analysis was performed for a range of recidivism rates and cost data, as shown in Table 1. Threshold analysis was also done to identify the values at which the cost effectiveness of our 2 treatment arms was equivalent. Equivalence in costs occurred when recidivism rates for patients in the violence intervention program arm decreased from 2.5% to 2.3%, and also when recidivism rates for patients in the standard referrals arm increased from 4% to 4.1%. Cost equivalence was further

Table 2 Demographic and clinical characteristics of patients with firearm injuries

Variable	Groups		
	Standard referrals (n = 355)	Caught in the crossfire (n = 156)	*P* value
Age	17.8 ± 0.1	17.8 ± 0.1	.9
Sex			
Female	31 (8.7%)	18 (11.5%)	[Reference]
Male	324 (91%)	138 (88%)	.32
Race			
White	15 (4%)	4 (3%)	[Reference]
Black	207 (58%)	97 (62%)	.41
Latino	119 (34%)	47 (30%)	.45
Asian	5 (1%)	4 (2%)	.36
Other	9 (2%)	4 (2%)	.96
Median Income*	$49,490 ± 940	$46,407 ± 1,235	.06
Insurance			
Private	33 (10%)	14 (9%)	[Reference]
Public	201 (59%)	106 (69%)	.04
Uninsured	105 (31%)	33 (22%)	.03
ISS	8.9 ± .4	13.4 ± .85	<.001
RTS	7.6 ± .05	7.5 ± .11	.1
M-GCS	5.88 ± .04	5.7 ± .09	.08
SBP	133 ± 1.4	128 ± 2.3	.09
Disposition after ED			
Discharge	179 (50%)	41 (26%)	[Reference]
Operating room	64 (18%)	44 (28%)	.01
Admission	112 (32%)	70 (45%)	.003
Hospital LOS	4.4 ± .37	6.9 ± .79	<.001
ICU LOS	5.8 ± .81	6.2 ± .98	.74
Recidivism (1 year)	14 (4%)	4 (2.5%)	.52

Analysis was done by Student *t* test for continuous variables and chi-square test for dichotomous or nominal variables.

ED = emergency department; ICU = intensive care unit; ISS = Injury Severity Score; LOS = length of stay; M-GCS = motor portion of the Glasgow Coma Score; RTS = revised trauma score; SBP = systolic blood pressure.

*Median income determined by zip code from census data.

found in the following circumstances: when the cost of hospitalization for recidivists in the intervention arm decreased to $6,006 and, conversely, when the cost of hospitalization for recidivists in the control arm increased to $19,038.

Bivariate sensitivity analysis was also performed on recidivism rates and hospitalization costs, the results of which can be seen in Figs. 2 and 3. In Fig. 2, a range of annual recidivism rates for HVIP participants is plotted against a range of recidivism rates for nonparticipants. The bisecting line of the graph represents equal cost effectiveness, above which the HVIP arm dominates. This figure thus illustrates the absolute difference in recidivism rates that would allow for an HVIP to be cost effective. In a similar vein, Fig. 3 shows the same graphical representation between hospitalization costs after recidivism.

Comments

The literature on violent injury recidivism demonstrates that this problem is chronic and damaging, yet also treatable with the proper social interventions.[4] HVIPs offering intensive case management services have proven to be effective in decreasing violent injury recidivism for its participants. However, the cost-effectiveness of such programs has yet to be determined. As such, in this dedicated cost-effectiveness analysis, we compared HVIPs with standard emergency department counseling and referrals to test whether one treatment strategy results in cost and quality of life benefits. Our hypothesis was that our HVIP is cost effective.

In our analysis, the costs and QALYs for both treatment arms were essentially identical. For example, our base case values for cost differed only by $59, and the resulting difference in QALYs was .02. This translated to an incremental cost effectiveness ratio for our violence intervention program of $2,941/QALY, which is much lower than accepted criteria for cost effective public health interventions.[23] Furthermore, threshold analysis revealed that the values at which equivalence was obtained in our model was very close to the values utilized in our base case model. In total, these findings suggest that our HVIP is, at worst, noninferior to the standard risk reduction services offered in our emergency department. In this sense, we consider our program to be cost effective, insofar as we believe money to be better spent preventing recurrent violent injury

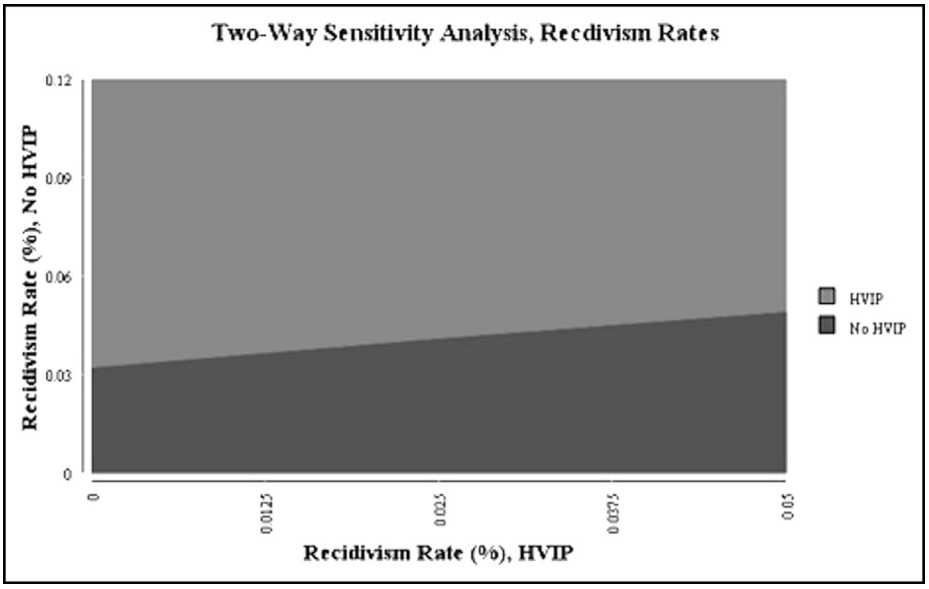

Figure 2 Graphical representation of a 2-way sensitivity analysis based on a range of annual recidivism rates.

rather than treating its consequences. Moreover, as this study was done from a healthcare perspective, our model does not take into account the savings our program achieves from a societal perspective. Previous research from our institution shows that this cost reduction is on the magnitude of $750,000 to $1 million annually.[6]

The findings from our sensitivity analyses also highlight some important points about the potential cost effectiveness of HVIPs. First, the cost benefit of any such program hinges on the difference in recidivism rate between treatment and control arms. Simply stated, a violence intervention program can only be cost effective if its clients have a significantly lower recidivism rate than program nonparticipants, a difference that is most starkly demonstrated when baseline community recidivism rates are high. Second, cost effectiveness in our model was also largely dependent on hospitalization costs after recidivism. In our experience, the cost of hospitalization after recidivism is markedly affected by whether a patient is a client of our HVIP. Nonparticipants faced higher costs and longer hospital stays after recidivism when compared with program clients, which is reflected in our model. For example, only 3% of recidivists from our violence intervention program had hospital stays of 10 days or longer, compared with 17% of program nonparticipants. In effect, our model thus demonstrates that the up-front costs of providing case management services for clients are replaced in the control group by higher costs of hospitalization after recidivism.

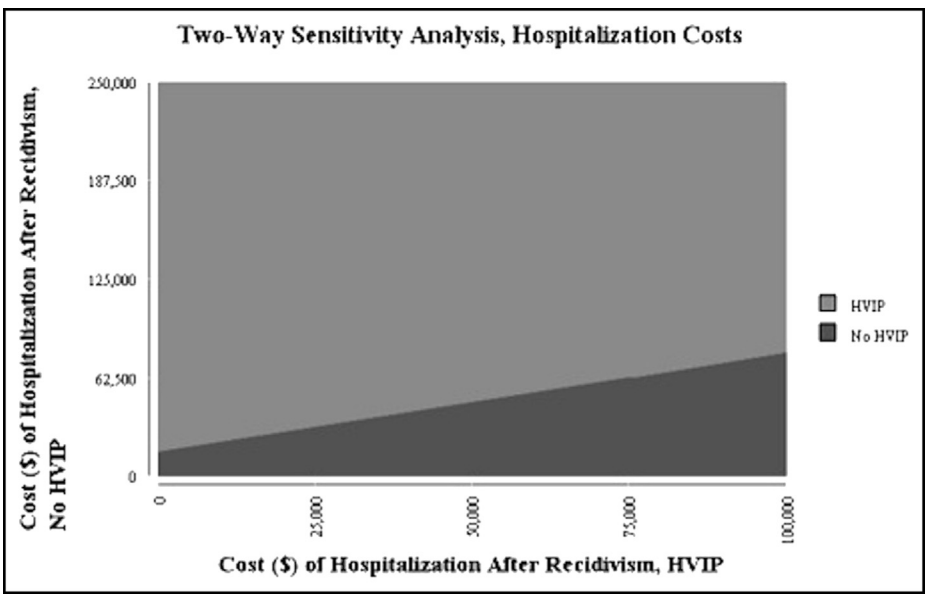

Figure 3 Graphical representation of a 2-way sensitivity analysis based on a range of recidivism hospitalization costs.

The difference in recidivism hospitalization costs between groups may suggest an as-of-yet unexplored benefit to violence intervention programs. Even if violence intervention programs are unable to completely prevent recidivist events for some individuals, there might be a mitigating effect to the severity of future episodes of recurrent injury. This may also be partially explained by the clinical differences between groups during the index injury. As clients of our violence intervention program had higher injury severity scores, longer hospital stays, and were more likely to need an admission and/or emergency operation during their index hospitalization, perhaps their teachable moment, which is a principle behind which violence intervention programs work, was more inviting of change than the control group. This behavioral motivation, if present, combined with the support and case management offered by violence intervention programs may then influence the probability and severity of future injury recidivism.

Like all cost analyses, our study navigated a number of limitations, many of which dealt with the balance between the complexity of real-life patient experiences and the simplicity of the decision model. As described in our Methods section, our model does not take into account the multitude of clinical outcomes that are categorized within the health state of "well." However, such complexity would be impossible to capture in a decision analysis and, also, would more likely impact future societal costs, rather than hospital costs. As such, we focused our model on the healthcare perspective, in an attempt to determine the potential cost benefit of violence intervention programs for the hospitals that house them. Furthermore, the accuracy of our model would have benefited from using actual hospital costs, but these data were not available to us. Instead, we rely on hospital charge data, which have been converted to costs using accepted cost-effectiveness research methods.[9]

Conclusions

HVIPs have proven to be an essential tool for trauma centers to address high rates of interpersonal violence and subsequent recurrent violent injury. Accordingly, violence intervention programs have begun to proliferate in hospitals and trauma centers across the nation. It is thus imperative that we document the clinical- and cost-effectiveness of these programs, as well as the clinical and social contexts within which they are, or are not, successful. As injury surveillance and prevention needs assessments are a required part of the trauma center verification process, this is a good example of tailoring proven services to the needs of the community being served.

In conclusion, in this decision analysis, we found our HVIP to be cost-effective when compared with standard risk reduction services offered in the emergency department. Studies from other centers, as well as cost analyses from a societal perspective, are needed to paint a fuller picture of the cost-effectiveness of such programs nationally.

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