Cost—Benefit Analysis Simulation of a Hospital-Based Violence Intervention Program

Jonathan Purtle, DrPH, Linda J. Rich, MA, Sandra L. Bloom, MD, John A. Rich, MD, Theodore J. Corbin, MD

Background: Violent injury is a major cause of disability, premature mortality, and health disparities worldwide. Hospital-based violence intervention programs (HVIPs) show promise in preventing violent injury. Little is known, however, about how the impact of HVIPs may translate into monetary figures.

Purpose: To conduct a cost—benefit analysis simulation to estimate the savings an HVIP might produce in healthcare, criminal justice, and lost productivity costs over 5 years in a hypothetical population of 180 violently injured patients, 90 of whom received HVIP intervention and 90 of whom did not.

Methods: Primary data from 2012, analyzed in 2013, on annual HVIP costs/number of clients served and secondary data sources were used to estimate the cost, number, and type of violent reinjury incidents (fatal/nonfatal, resulting in hospitalization/not resulting in hospitalization) and violent perpetration incidents (aggravated assault/homicide) that this population might experience over 5 years. Four different models were constructed and three different estimates of HVIP effect size (20%, 25%, and 30%) were used to calculate a range of estimates for HVIP net savings and cost—benefit ratios from different payer perspectives. All benefits were discounted at 5% to adjust for their net present value.

Results: Estimates of HVIP cost savings at the base effect estimate of 25% ranged from $82,765 (narrowest model) to $4,055,873 (broadest model).

Conclusions: HVIPs are likely to produce cost savings. This study provides a systematic framework for the economic evaluation of HVIPs and estimates of HVIP cost savings and cost—benefit ratios that may be useful in informing public policy decisions.


Introduction

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HVIPs provide brief intervention in the hospital, needs assessment, and therapeutic case-management services to connect violently injured patients with resources that reduce risk of violent reinjury and perpetration.7,8 HVIP services are provided by case workers who understand the life experiences of violently injured patients. HVIPs are grounded in empirical data about the recurrent nature of violent injury9–26 and the theory that hospitals offer a unique opportunity for intervention.7,8

HVIPs have shown effectiveness in preventing violent reinjury and perpetration; in improving employment, education, and healthcare utilization; and in reducing aggressive behaviors.14,27–32 More than 20 HVIPs operate across the U.S. under the National Network of Hospital-Based Violence Intervention Programs (NNHVIP)33 and well-established HVIPs have begun to be replicated.34 The U.S. Department of Justice (DOJ) has acknowledged the value of HVIPs, recommending that "Hospital-based
counseling and prevention programs should be established in all hospital emergency departments (EDs)—especially those that provide services to victims of violence” (p. 13). Several cities participating in DOJ’s National Forum on Youth Violence Prevention are integrating HVIPs into their strategic plans.

HVIPs are proliferating across the U.S. and research is documenting their effectiveness. Little is known, however, about their economic impacts. Understanding HVIPs’ costs and benefits and distribution across different sectors is important because it will impact HVIP sustainability. The primary aim of this study is to develop a cost–benefit analysis (CBA) framework for HVIPs. Secondary aims are to conduct a CBA simulation of an HVIP, produce preliminary estimates of HVIP cost–benefits, and identify priorities for future HVIP effectiveness and violence prevention research.

Methods
The best secondary data sources available as of 2013 were used to simulate the violent reinjury and perpetration outcomes likely to be experienced by a hypothetical population of 180 violently injured patients, 90 of whom received HVIP intervention and 90 of whom did not, in the 5 years after a violent injury resulting in hospital care. Estimates of the outcomes in these two groups were compared and the monetary costs associated with each were summed to estimate the cost savings that an HVIP would produce over 5 years, assuming different HVIP effect sizes. Ninety was the number chosen for each group because it is the approximate number of clients an HVIP serves in 1 year. Although most HVIP services are provided in the first year after injury, 5 years was selected as the time frame for the simulation because HVIPs connect patients with resources (e.g., education and employment) that have enduring risk-reduction benefits.

Two major cost–benefit pathways were identified through which an HVIP could produce cost savings—preventing violent reinjury and preventing violent perpetration (Figure 1).

Cost Estimates
Four categories of costs were included in the CBA simulation (Table 1). Average annual HVIP operating costs were estimated from a 2012 survey of directors of NNHVIP member programs. Cost inputs included three full-time HVIP case workers, one full-time administrative/research staff member, one part-time emergency physician/trauma surgeon, staff benefits, case management database, and overhead.

Estimates reported by Corso et al. of lifetime healthcare and lost productivity costs associated with nonfatal and fatal injuries were used and adjusted for 2011 healthcare dollars. For fatal injuries, the lost productivity estimates for boys and men aged 15–24 years were used because HVIPs predominantly serve this demographic group. Estimates reported by DeLisi and colleagues of costs associated with cases of violent perpetration were used and adjusted for 2011 U.S. dollars. This previous analysis estimated the criminal justice costs associated with cases of homicide and aggravated assault resulting in conviction.
HVIP, hospital-based violence intervention program.

reinjuries resulting in hospitalization, translating into 37 incidents. 30% of patients sustained an average of 1.38 nonfatal violent
in the hypothetical control population (90\(\times\)0.045=4.05), and that 30% of patients sustained an average of 1.38 nonfatal violent
reinjuries resulting in hospitalization, translating into 37 incidents (\([90\times0.3]\)×1.38=37.26). The estimate of 1.38 was generated by
calculating the weighted mean of the average number of reinjuires reported in the identified studies.\(^{3,11,12}\) Injury surveillance data were used to estimate the number of violent injuries not resulting in hospitalization that occur for every
one that does. According to U.S. CDC data,\(^{29}\) among boys and men aged 15–24 years, an estimated 376,653 incidents of nonfatal
violent injury were treated in hospitals in 2011, and 40,148 of those resulted in hospitalization or critical care transfer (a ratio of
8.38:1.0). Therefore, the estimate of the number of nonfatal violent reinjuries resulting in hospitalization was multiplied by 8.38 to
produce an estimate of the number resulting in hospitalization (37.26×8.38=312.2).

When an incident of violent perpetration occurs, the perpetrator
incurs criminal justice and lost productivity costs only if the incident results in police involvement. The victim of violent
perpetration, however, incurs healthcare and lost productivity
costs regardless of whether the incident is reported to police. Therefore, the costs incurred by the perpetrator and the victim
(Figure 1) were considered separately.

One study was identified that documented the 5-year incidence of
homicide conviction after hospital-treated violent injury. Sims
et al.\(^{29}\) found that 1.14% of violently injured patients were convicted of homicide within 5 years, translating into 1 homicide conviction
(90\(×\)0.0114=1.026). No studies were located that assessed the
5-year incidence of aggravated assault conviction after hospital
treatment for violent injury. To address this issue, criminal justice
data were used to estimate the number of assault convictions that
occur for every one homicide conviction. A DOJ report\(^{44}\) provided
data on outcomes of state court felony proceedings in large urban
counties in the U.S. between 1990 and 2002. In this period, there
were 12,950 aggravated assault convictions and 1,077 homicide
convictions, for a ratio of 12.02:1.0. Therefore, the estimate of the
number of homicide convictions was multiplied by 12.02 to
estimate the number of aggravated assault convictions, translating
to 12 aggravated assault convictions (1.026×12.02=12.33).

Only 64.8% of homicides/manslaughters and 56.9% of aggra-
vated assaults reported to the police were cleared by arrest in
2011.\(^{45}\) Assuming that all of these arrests result in conviction, the estimate of the number of homicide convictions was multiplied by
1.54 (1.0 – 0.648=1.54) and the estimate of the number of aggravated assault convictions was multiplied by 1.76
(1.0 – 0.569=1.76) to estimate the number of homicides (1.026×1.54=1.58) and aggravated assaults (12.33×1.76=21.70) that would occur. The ratio of nonfatal violent injuries not
resulting in hospitalization to those resulting in hospitalization
presented here (8.38:1.0) was used to estimate the proportion of
nonfatal aggravated assaults resulting in hospitalization, trans-
lating to three resulting in hospitalization (21.70 – 8.38=21.32) and
19 not resulting in hospitalization (21.70 – 2.58=19.12).

Studies evaluating HVIP effectiveness were identified through a
systematic review of youth-focused HVIPs,\(^{26}\) narrative reviews of
HVIPs,\(^{7,8}\) review of the references of these publications, and use of
Google Scholar to identify articles citing these publications. Five
studies that documented the incidence of violent reinjury and
violent perpetration with HVIP intervention were identified
(Appendix Table 2; available online).\(^{14,27–30}\) Methodologic differ-
cences between HVIP evaluations prohibited pooling of results. The
review of HVIPs suggested that they are effective in preventing
violent reinjury. Based on the empirical evidence of HVIPs,\(^{14,27–29}\) it was estimated that HVIPs reduce the 5-year incidence of violent
reinjury by 25%. Therefore, each reinjury outcome estimate for the
population without HVIP intervention was multiplied by 0.75 to

by summing the costs of investigation, legal defense, incarcer-
ation, probation, and parole. The corresponding productivity
losses reported were also used.

**Outcome Estimates**

Searches were conducted in PubMed for *violent reinjury* and
*violent injury recidivism*; the references of these publications were
reviewed, and Google Scholar was used to locate articles citing
these publications to identify studies conducted in the U.S. that
reported data on the 5-year incidence of violent reinjury when the
initial violent injury and violent reinjury both resulted in hospital
care. This type of reinjury was the focus because hospital-treated
violent injury is an inclusion criterion for receiving HVIP services
and because of the CBA’s emphasis on healthcare costs associated
with violent reinjury. Six studies were identified (Appendix
Table 1; available online).\(^{2,3–14}\) The reinjury rate ranged from
2.9% to 44%. Methodologic differences between the studies (e.g.,
method of assessing initial injury and reinjury and number of
hospitals included in the study) prohibited pooling of results. It
was estimated that 4.5% of violently injured patients sustained a
fatal violent reinjury within 5 years, translating into four incidents
in the hypothetical control population (90\(×\)0.045=4.05), and that 30%
of patients sustained an average of 1.38 nonfatal violent
reinjuries resulting in hospitalization, translating into 37 incidents
\([90\times0.3]\)×1.38=37.26). The estimate of 1.38 was generated by
calculating the weighted mean of the average number of reinjuires reported in the identified studies.\(^{3,11,12}\)

**Table 1. Summary of Cost Estimates**

<table>
<thead>
<tr>
<th>HVIP Intervention Costs</th>
<th>Healthcare Costs</th>
<th>Criminal Justice Costs</th>
<th>Lost Productivity Costs</th>
</tr>
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<tbody>
<tr>
<td></td>
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</tr>
<tr>
<td>Annual cost to serve 90 clients</td>
<td>$350,000</td>
<td>Nonfatal violent reinjury resulting in hospitalization</td>
<td>$37,260</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nonfatal violent reinjury not resulting in hospitalization</td>
<td>$1,533</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fatal violent reinjury resulting in medical care</td>
<td>$7,251</td>
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<tr>
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<tr>
<td></td>
<td></td>
<td>Homicide conviction</td>
<td>$321,111</td>
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<tr>
<td></td>
<td></td>
<td>Aggravated assault conviction</td>
<td>$14,450</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nonfatal violent reinjury resulting in hospitalization</td>
<td>$74,730</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nonfatal violent reinjury not resulting in hospitalization</td>
<td>$3,686</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fatal violent reinjury</td>
<td>$2,189,698</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Homicide conviction</td>
<td>$149,851</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aggravated assault conviction</td>
<td>$6,850</td>
</tr>
</tbody>
</table>

\(^{2}\)2011 U.S. dollars.

\(^{3}\)All age groups.

\(^{4}\)Men and boys ages 15–24 years.

HVIP, hospital-based violence intervention program.
produce estimates of outcomes with HVIP intervention (e.g., 37.26×0.75=28.0 for nonfatal violent reinjury resulting in hospitalization).

No studies were identified that assessed the effect of HVIPs on preventing homicide or aggravated assault perpetration. Two studies, however, provided data that allowed generation of estimates. In an RCT, Cooper et al.27 found that the HVIP group was four times less likely to be convicted of violent crime than the control group (13% vs 55%). In a quasi-experimental evaluation, Shibru and colleagues29 found that the incidence of violent crime perpetration was significantly lower among subjects in the HVIP group than the control group (9% vs 16%). Zun et al.,28 however, found no difference in rates of arrest (7.5% vs 7.4%) between the HVIP and control groups in an RCT. Working within the limitations of the published literature, it was estimated that HVIPs reduce the 5-year incidence of violence perpetration by 25%. Accordingly, each violence perpetration outcome estimate for the population without HVIP intervention was multiplied by 0.75 to produce estimates of outcomes with HVIP intervention (e.g., 12.33×0.75=9.25 for aggravated assault conviction).

Analyses

A sensitivity analysis was conducted to produce a range of estimates for all outcomes according to varying assumptions of HVIP effect size. Estimates of the number and type of violent reinjury and violent perpetration outcomes were calculated according to HVIP effect estimates 5 percentage points below (i.e., 20%) and 5 percentages points above (i.e., 30%) the base HVIP effect estimate of 25%.

Four different models were constructed to estimate the range of HVIP cost—benefits from different payer perspectives (Table 2). All future HVIP benefits were discounted at a conservative rate of 5%.27 All HVIP intervention costs were assumed to be expended in Year 1 and benefits were assumed to be produced uniformly over 5 years. All costs and benefits were standardized in 2011 U.S. dollars.

All calculations were performed in Excel (Microsoft Corporation, Redmond WA; results available upon request). For each model and assumption of HVIP effect size, estimates of the number of violent injury and perpetration outcomes were multiplied by their corresponding costs to produce a total sum of costs. This was done separately for the group receiving HVIP intervention and the group not receiving HVIP intervention. Intervention costs ($350,000) were added to the total sum of costs for the group receiving HVIP intervention. The total sum of costs for the group receiving HVIP intervention was then subtracted from the sum of costs for the group not receiving HVIP intervention to produce an estimate of the net benefit produced over 5 years. It was assumed that these benefits were produced uniformly over 5 years and future benefits were discounted at a rate of 5% annually, adjusting estimates of cost savings for their net present value. Net benefits were divided by intervention costs ($350,000) to produce cost—benefit ratios.

Results

The HVIP produced cost savings over 5 years in all models according to most assumptions of HVIP effect size (Table 3). At the base effect estimate of 25%, HVIP cost savings ranged from $82,765 (Model 1) to $4,055,873 (Model 4), and 83 incidents of nonfatal violent reinjury not resulting in hospitalization, 10 resulting in hospitalization, 1 fatal violent injury, and 3 cases of aggravated assault conviction prevented (Table 4).

Discussion

Secondary data were used to estimate the potential costs and benefits of an HVIP over 5 years from different payer perspectives. The results indicate that HVIPs are likely to produce cost—benefits from healthcare, public sector, and societal perspectives. The amounts of cost-savings estimates produced by this analysis are modest compared with those of other economic evaluations of HVIPs. Cooper et al.27 calculated the monetary value of outcomes observed in an RCT and concluded that the HVIP saved approximately $1.25 million in criminal justice costs and $598,000 in healthcare costs over 2 years. Smith and colleagues30 found that healthcare costs savings would render an HVIP cost-neutral if it prevented 3.5 injuries per year. The relatively modest results reported in the present study are partially explained by the fact that Cooper et al. ($46,000) and Smith et al. ($49,000) used higher cost estimates for violent injury resulting in hospitalization and observed effect sizes that exceeded estimates used in the current study.

This study focused on cases of violent reinjury in which the initial violent injury and subsequent violent injury both resulted in hospital care. Thus, the study did not account for violent reinjuries not resulting in medical care and should be considered within the broader context of violent reinjury research. Gallagher25 found that only 19% of people reporting violent injuries sought hospital care and that people not seeking care were at higher risk for violent reinjury than those who did seek care (13% vs 6%). A survey of youth presenting to an emergency department (ED), regardless of chief complaint, found that 9.6% reported sustaining a violent injury resulting in medical treatment in the past year.48 A similar study of
adults found that 11.0% reported being assaulted in the past year and a study using Monitoring the Future survey data found a 1-year violent reinjury rate of 8.8% among high school students, but the proportion of injuries resulting in hospital care was not reported in either study. Furthermore, this study focused on violent reinjury at 5-year follow-up and should be considered within the context of research that has assessed violent reinjury at different follow-up periods. The present study highlights the need for a systematic review of the violent reinjury literature.

The analysis reported here is based on numerous assumptions and has several limitations. The estimates of the incidence of violent reinjury are likely low because most studies assessed reinjury at a single hospital and a previous or subsequent violent injury could have been treated at a different hospital. Kennedy et al. found that only 42% of violently reinjured patients received treatment for their initial injury in the same hospital where their reinjury was treated. Because HVIPs prevent violent reinjuries and their associated costs, underestimating the incidence of violent reinjury would also underestimate the cost—benefits of HVIPs. Future research linking injury records across hospitals would enhance the rigor of economic evaluations of HVIPs.

Relatively short follow-up periods (i.e., 1–2 years) in most HVIP outcome evaluations limited the precision of the 5-year HVIP effect estimates reported here. Some evidence, however, suggests that the 5-year base effect estimate of 25% is an underestimate. For 6 years, Smith and colleagues prospectively collected data on incidents of violent reinjury among HVIP clients and found that 6% experienced violent reinjury, compared with a 5-year reinjury rate of 15% that Tellez et al. documented at the same hospital before the intervention—a 60% reduction. Future evaluations of HVIPs should document outcomes over extended time periods. Publically available data sources, such as death certificates and criminal justice records, provide a means to track long-term violent reinjury and perpetration outcomes.

The extrapolation of ecologic data limits the precision of outcome estimates. The ratio of violent injuries not resulting in hospitalization to violent injuries resulting in hospitalization and the ratio of aggravated assault convictions to homicide convictions may not be generalizable to a population that experiences violent reinjury and is unlikely uniform across all regions in the U.S. The cost estimates used are also not generalizable to all regions in the U.S. The criminal justice cost estimates of DeLisi and colleagues were generated from only 8 states and although the healthcare cost estimates of Corso et al. were nationally representative, the cost of health care varies substantially between regions.29,50

Table 3. Estimates of HVIP Cost—Benefits

<table>
<thead>
<tr>
<th>HVIP effect estimate (%)</th>
<th>Model 1 Healthcare perspective</th>
<th>Model 2 Healthcare perspective</th>
<th>Model 3 Public sector perspective</th>
<th>Model 4 Societal perspective</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>(3,788)</td>
<td>82,765</td>
<td>169,319</td>
<td>314,698</td>
</tr>
<tr>
<td>25</td>
<td>21,270</td>
<td>206,840</td>
<td>345,609</td>
<td>493,747</td>
</tr>
<tr>
<td>30</td>
<td>229,868</td>
<td>345,609</td>
<td>493,747</td>
<td>641,887</td>
</tr>
<tr>
<td>Cost—benefit ratio</td>
<td>0.99</td>
<td>1.24</td>
<td>1.48</td>
<td>1.76</td>
</tr>
<tr>
<td>Cost savings ($)</td>
<td>(3,788)</td>
<td>82,765</td>
<td>169,319</td>
<td>314,698</td>
</tr>
<tr>
<td>Over 5 years, net present value discounted at 5% 2011 U.S. dollars.</td>
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</tbody>
</table>

HVIP, hospital-based violence intervention program.
The analysis reported here assumes that HVIPs had a homogeneous effect over 5 years because the existing research was insufficient to support estimates of risk and HVIP effect at different time points. Some studies, however, suggest that risks are highest, and that HVIPs are most effective in the first year after violent injury. Madden et al.\(^{17}\) found that 30% of patients receiving ED care for a violent injury had received care for a violent injury within 1 year. The risks of violent perpetration may also be highest in the period immediately after violent injury, as some patients seek retaliation against their perpetrator(s).\(^{51}\) Because the present study discounted future benefits at an annual rate of 5%, assumptions of when HVIPs produce outcomes have implications for the estimates of HVIP cost savings. If HVIPs have heterogeneous effects over 5 years and produce more outcomes (i.e., prevent reinjury and perpetration) earlier rather than later, the assumption of a homogeneous effect would lead to underestimation of cost/benefits. Assuming that 10% of violently injured patients in the hypothetical control population sustain a violent reinjury resulting in hospitalization (90\(^{th}\) percentile), a 1-year HVIP effect estimate of 25% (9.675\(\times\)2.25) translating to $74,520 in healthcare cost savings. If HVIPs have heterogeneous effects over 5 years and produce more outcomes (i.e., prevent reinjury and perpetration), the estimates of cost/benefits would be produced at a willingness to pay (WTP) of $350,000 ($74,520\(\div\)90). In addition to the high likelihood of these costs being offset by healthcare and criminal justice savings, Cohen et al.\(^{52}\) estimated a societal WTP of $11.8 million for preventing one murder and $85,000 for a violent injury that had received care for a violent injury in the first year after violent injury. The risks of violent perpetration may also be highest in the period immediately after violent injury, as some patients seek retaliation against their perpetrator(s).\(^{51}\) Because the present study discounted future benefits at an annual rate of 5%, assumptions of when HVIPs produce outcomes have implications for the estimates of cost/benefits. If HVIPs produce outcomes have implications for the estimates of cost/benefits.

### Table 4. Estimates of Outcomes 5 Years After a Violent Injury

<table>
<thead>
<tr>
<th>Without HVIP intervention (n=90)</th>
<th>With HVIP intervention (n=90)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No. of incidents</strong></td>
<td><strong>Incidence rate per 100 person-years at risk</strong></td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>HVIP effect estimate (%)</td>
<td>NA</td>
</tr>
<tr>
<td>Violent reinjury pathway</td>
<td>Nonfatal violent reinjury resulting in hospitalization</td>
</tr>
<tr>
<td></td>
<td>Nonfatal violent reinjury not resulting in hospitalization</td>
</tr>
<tr>
<td></td>
<td>Fatal violent reinjury resulting in medical care</td>
</tr>
<tr>
<td>Violent perpetration pathway</td>
<td>Nonfatal violent injury resulting in hospitalization</td>
</tr>
<tr>
<td></td>
<td>Nonfatal violent injury not resulting in hospitalization</td>
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<tr>
<td></td>
<td>Fatal violent injury resulting in medical care</td>
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<tr>
<td></td>
<td>Homicide conviction</td>
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<td></td>
<td>Aggravated assault conviction</td>
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HVIP, hospital-based violence intervention program; NA, not applicable.
preventing one aggravated assault. The results of this CBA simulation should be considered within the context of evidence about society’s desire to prevent violence for reasons beyond healthcare and criminal justice costs.

Conclusions

This CBA simulation provides preliminary support for the conclusion that HVIPs produce cost savings. Although the CBA framework constructed in this study should be tested through future research, the results reveal a possible financial incentive for state Medicaid and Victims of Crime Assistance agencies to explore reimbursement mechanisms that aid HVIP sustainability.

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References


Appendix

Supplementary data

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