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Identifying Patterns of Health Care Utilization among Physical Elder Abuse Victims Using Medicare Data and Legally Adjudicated Cases: Protocol for Case-Control Study using Data Linkage and Machine Learning

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24 **Identifying Patterns of Health Care Utilization among Physical Elder Abuse Victims Using**
25 **Medicare Data and Legally Adjudicated Cases: Protocol for Case-Control Study using**
26 **Data Linkage and Machine Learning**
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Abstract

Introduction: Physical elder abuse is common and has serious health consequences but is under-recognized and under-reported. As assessment by health care providers may represent the only contact outside family for many older adults, clinicians have a unique opportunity to identify suspected abuse and initiate intervention. Preliminary research suggests elder abuse victims may have different patterns of health care utilization than other older adults, with increased rates of Emergency Department use, hospitalization, and nursing home placement. Little is known, however, about the patterns of this increased utilization and associated costs. To help fill this gap, we describe here the protocol for a study exploring patterns of health care utilization and associated costs for known physical elder abuse victims compared to non-victims.

Methods and Analysis: We hypothesize that various aspects of health care utilization are differentially affected by physical elder abuse victimization, increasing ED/hospital utilization and reducing outpatient/primary care utilization. We will obtain Medicare claims data for a series of well-characterized, legally adjudicated cases of physical elder abuse to examine victims' health care utilization before and after the date of abuse detection. We will also compare these physical elder abuse victims to a matched comparison group of non-victimized older adults using Medicare claims. We will use machine learning approaches to extend our ability to identify patterns suggestive of potential physical elder abuse exposure. Describing unique patterns and associated costs of health care utilization among elder abuse victims may improve the ability of health care providers to identify and, ultimately, intervene and prevent victimization.

Ethics and Dissemination: This project has been reviewed and approved by the Weill Cornell Medicine Institutional Review Board, protocol #1807019417, with initial approval on August 1,

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2
3 2018. We aim to disseminate our results in peer-reviewed journals, at national and international
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5 conferences and among interested patient groups and the public.
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9 **Keywords:** elder abuse; elder mistreatment; health care utilization; machine learning; research
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For peer review only

Article Summary: Strengths and limitations of this study:

- We explore patterns of health care utilization and associated costs for known physical elder abuse victims, about common and serious phenomenon about which little is known
- We use Medicare claims data for a series of well-characterized, legally adjudicated cases of physical elder abuse to comprehensively examine victims' health care utilization before and after the date of abuse detection in comparison to non-victimized older adults algorithmically selected from Medicare claims
- We use machine learning approaches to better identify patterns suggestive of potential physical elder abuse exposure
- Though using legally adjudicated cases solves the important methodologic challenge of ensuring that case subjects are actually victims of abuse, these cases represent a small percentage of all elder abuse cases and their experience of abuse may differ in important ways from other victims
- Subjects must have been enrolled in Medicare Fee-for-Service rather than Medicare Advantage or another insurance for us to be able to examine their health care utilization

Introduction

Elder abuse is common and has serious health consequences but is under-recognized and under-reported. As many as 10% of US older adults experience elder abuse each year.¹⁻⁶ This maltreatment may include physical abuse, sexual abuse, neglect, psychological abuse, or financial exploitation, and many victims suffer from multiple types of abuse concurrently.¹⁻⁵ Evidence suggests that elder abuse is associated with adverse health outcomes, including disability,⁷ dementia,⁸ depression,⁸ and mortality.⁹⁻¹¹ Despite its frequency, many elder abuse victims endure it for years before having it discovered or dying. Studies suggest that as few as 1 in 24 cases of elder abuse is reported to the authorities,^{1,3,12} and some of the associated morbidity and mortality is likely due to this delay in identification and intervention.¹³

As assessment by health care providers may represent the only outside contact for many older adults, so clinicians have a unique opportunity to identify suspected elder abuse and initiate intervention.¹⁴⁻²⁰ Elder abuse victims have increased rates of emergency department (ED) use,^{14,17} hospitalization,²¹ and nursing home placement.^{22,23} Little is known, however, about the patterns of this increased utilization and associated costs.^{5,24} Influential research in child abuse²⁵⁻³⁰ and intimate partner violence^{31,32} has focused on health care utilization before identification, highlighting that many victims had multiple previous visits for likely abuse-related issues, suggesting “missed opportunities” for identification and early intervention. Child abuse researchers have found that minor abusive injuries, “sentinel injuries,” are commonly found in children who are subsequently victims of severe child abuse but rare in those who aren’t.^{33,34} Strategies are being developed to capitalize on these findings to prevent morbidity and mortality for victims. Additionally, research has found that health care costs were significantly higher for victims of child abuse and intimate partner violence both in the short-term^{35,36} and long-term,^{35,37-40} compared to costs incurred by non-victims. These increased costs represent a key

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3 component of the overall economic burden of these phenomena,⁴¹⁻⁴⁴ and related research
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5 findings have been critical in revealing the scope and impact of child abuse and intimate partner
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7 violence and in driving policymaking decisions. We know of no analogous research in elder
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9 abuse.
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12 To help fill this gap in the literature, we describe here the protocol for a study designed to
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14 explore in detail patterns of health care utilization and associated costs for known physical elder
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16 abuse victims compared to non-victims using analytic techniques including machine learning.
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Methods and Analysis

Conceptual Framework and Hypotheses

We hypothesize that various aspects of health care utilization are differentially affected by physical elder abuse victimization. Many issues related to physical elder abuse potentially increase ED/hospital utilization and reduce outpatient/primary care utilization. We have developed a conceptual framework (Figure 1) to explain this pattern. This framework is informed by a model for elder abuse research that members of our team developed as part of the National Institute on Aging (NIA) Workshop “Multiple Approaches to Understanding and Preventing Elder Abuse and Mistreatment: Prevention and Intervention.”⁴⁵

As shown in Figure 1, we further hypothesize that physical elder abuse victims, due to their poor connection to primary care, will have increased utilization of EDs/hospitals for ambulatory care-sensitive conditions (ACSCs) and for non-urgent issues. ACSCs are conditions that, if treated in a timely fashion with adequate primary care and managed properly on an outpatient basis, should not advance to the point where an ED visit or hospitalization is required.⁴⁶ Measuring the rate of use of high intensity, high cost services to treat these conditions is common in health services research to assess access to and quality of primary care.⁴⁶⁻⁴⁹ Similarly, use of the ED for non-urgent issues suggests inappropriate use in the absence of primary care.

We also hypothesize that physical elder abuse victims will have high rates of repeat ED visits and re-hospitalizations within short intervals. This results from poor connections to primary care and poor adherence to outpatient follow-up care recommendations.⁵⁰⁻⁵³ We anticipate that physical elder abuse victims will also have higher use of the ED/hospital for issues directly related to abuse, including presentation for injuries and use of imaging to evaluate

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3 specific injury types. Based on anecdotal experiences by elder abuse experts,⁵⁴ we also
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5 hypothesize that, compared to other older adults, physical elder abuse victims will more likely be
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7 seen at multiple EDs and hospitals. This “hospital hopping” often occurs to avoid abuse
8
9 detection.⁵⁵
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12 Conversely, we hypothesize that poor access to and less frequent use of primary care will
13
14 be associated with more primary care provider changes, lower receipt of preventative services,
15
16 and worse continuity of care. More frequent changes in primary care providers result in fractured
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18 care and have been shown in previous claims-based research to be associated with child abuse.⁵⁶
19
20 Receipt of preventative services has been used in previous studies to assess level of primary care
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22 utilization among Medicare beneficiaries and has been shown to be lower in older adults with
23
24 low primary care access including excess alcohol use and poor health literacy.⁵⁷⁻⁶¹ We anticipate
25
26 that physical elder abuse victims will have lower continuity of care, which has been shown in
27
28 Medicare beneficiaries to be associated with increased rates of frequent ED use.⁶² Continuity of
29
30 care assesses the dispersion of outpatient evaluation and management visits, examining how
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32 many unique doctors a patient visits within a specific timeframe.⁶³
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38 And finally, we also hypothesize that victims of physical elder abuse, partially due to
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40 poor connection to primary care, will have poorer adherence to medications for chronic
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42 conditions, such as diabetes medications and anti-hypertensives, which has been shown to impact
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44 high intensity healthcare utilization and cost.^{64,65}
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49 *Study Design*

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51 In this retrospective study, we will obtain Medicare claims data for a series of legally
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53 adjudicated cases of physical elder abuse to comprehensively examine victims’ health care
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3 utilization before and after the date of abuse detection. We will also compare physical elder
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5 abuse victims to other non-victimized older adults. We will algorithmically select this
6
7 comparison group from Medicare claims data to be matched to the physical elder abuse victims.
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10 We will compare victims' ED/hospital and outpatient primary care utilization to that of
11
12 the control groups. We will use machine learning approaches to extend our ability to identify
13
14 patterns suggestive of potential physical elder abuse exposure.
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17 This project has been reviewed and approved by the Weill Cornell Medicine Institutional
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19 Review Board, protocol #1807019417 (initially approved on August 1, 2018). The Institutional
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21 Review Board approved waiving the requirement to obtain informed consent from subjects in
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23 this retrospective study.
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28 *Study Subjects*

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30 For this research, we plan to use a well-characterized series of 204 legally adjudicated
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32 cases of physical elder abuse from Brooklyn, New York and Seattle, Washington. The
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34 methodologic advantage of this series of cases is unique: because the perpetrators have pled
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36 guilty or been convicted, the presence of elder abuse has been verified and the time of detection
37
38 is known. This dataset includes rich information about the abuse victims and perpetrators as well
39
40 as details about the abuse history, when and how it was detected, and the surrounding
41
42 circumstances. It was constructed using information from the legal case files, including: medical
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44 records, descriptions of Emergency Medical Services personnel and police interactions with the
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46 victim and perpetrator, victim statements, adult protective services files, court documents, and
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48 photographs of injuries.
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Medicare Data Linkage

We will link these legally adjudicated cases to Medicare claims data using identifying information including social security numbers and/or a combination of last name, date of birth and residential ZIP code. Fee-for-service Medicare data is the largest single repository of patient health care data for US older adults,⁶⁶ offering comprehensive information on utilization of a broad range of health care services for continuously enrolled individuals. Medicare claims data has been used successfully to analyze health care utilization and costs and to inform interventions and policies for a variety of chronic diseases.⁶⁷⁻⁷⁰ Additionally, claims data have been used to examine the impact on utilization and cost of socio-medical issues^{71,72} including excessive alcohol use.^{47,57,73} Medicare claims data have also been employed to provide insight into the characteristics of frequent utilizers of specific health services, such as the ED^{62,74} and hospital.⁷⁵

We plan to examine Medicare claims data for each case from 3 years before to 3 years after detection of elder abuse and will compare to controls. We will use files including the Master Beneficiary Summary File (enrollee demographics, monthly enrollment information, chronic conditions, annual summary of costs and service utilization), Medicare Provider Analysis and Review (MEDPAR) file (events of inpatient hospital and skilled nursing facility stays), Outpatient Claims, Carrier File (claims of physician services), Home Health Claims, and the Part D (prescription drug) Event File.⁷⁶

Measures

We describe the key measures of utilization we plan to use in Table 1. We plan to focus primarily on utilization of high-intensity, high cost health care services including ED visits and hospitalizations by elder abuse victims and non-victim control subjects. We will examine overall

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3 utilization of these services and will also look at several characteristics of this utilization. We
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5 will examine the frequency of ED use and hospitalization among victims and compare utilization
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7 of these services of victims and non-victim controls. We will focus on injury-related utilization,
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9 using ICD codes and external cause of injury codes^{77,78} similar to previous work in child
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11 abuse.^{56,79} We will also examine frequent ED use, defined as 4 or more visits in a year, the cut-
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13 off accepted in the literature and used in previous Medicare research.^{62,74,80,81} We plan to
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15 measure the number of potentially avoidable low-urgency ED visits^{82,83} as well as ED visits and
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17 hospitalizations for ambulatory care-sensitive conditions (ACSCs). We will define low urgency
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19 visits similar to previous literature^{82,83} using Medicare Current Procedural Terminology (CPT)
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21 billing codes (99281, 99282) indicating low severity and no additional procedures billed. For this
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23 research, we will use the 11 ACSCs established for use in Medicare data.⁴⁶ We will also examine
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25 repeat ED visits and re-hospitalizations within short intervals. Consistent with previous research,
26
27 we will examine visits to the ED within 3 days, 7 days, and 30 days of initial visit^{50,52} as well as
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29 repeat hospitalizations within 30 days and 90 days of initial hospitalization.⁵¹ Additionally, we
30
31 will explore use of multiple EDs and hospitals.
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38 For outpatient care, we will examine the number of primary care visits and focus on
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40 injury-related visits for victims and controls. We will also examine changes in primary care
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42 providers. We plan to evaluate the continuity of care using the widely employed Continuity of
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44 Care Index (COCI).⁶³ Given that the COCI requires multiple outpatient visits to be meaningfully
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46 calculated, we will only examine this variable for subjects with three or more outpatient visits,
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48 consistent with previous literature.^{62,84,85} We will measure whether physical elder abuse victims
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50 and control subjects received preventative services, including influenza vaccination, glaucoma
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52 screening, pneumonia vaccination, and mammogram.⁵⁷ We plan to examine adherence to
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3 medication for chronic conditions. To do this, we will measure the proportion of days
4 covered^{86,87} and determine adherent vs. non-adherent using 0.80 as a cut-off, a common research
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6 strategy in administrative claims data.^{87,88}
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10 We will examine demographic data, including age, gender, and race/ethnicity. We will
11 also use claims data for key health-related co-variables to allow for further characterization of
12 physical elder abuse victims and comparison of sub-groups. These include medical co-
13 morbidities, psychiatric co-morbidities, dementia, and frailty. For medical co-morbidities, we
14 plan to use chronic condition indicators within the Medicare Master Beneficiary file, and we will
15 use psychiatric diagnoses within claims data. We will use an established approach^{35,89,90} to
16 identify dementia. To identify frailty, we will use a recently-developed algorithm designed for
17 use in Medicare claims data.^{91,92}
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31 *Non-Victim Control Subjects*

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33 We will select a group of non-victim control subjects matched to the cases on age, race,
34 gender, and residential ZIP code at the time of detection of each elder abuse case. This control
35 group will allow us to compare health care utilization of elder abuse victims with that of a
36 general older adult population. We will construct a second control group who, in addition to
37 being matched to the cases on age, race, gender, and ZIP code, visited the ED for an
38 unintentional injury within one week of the victim's abuse detection by law enforcement. This
39 second control group will allow us to explore potential differences between older adults
40 presenting to the ED for abuse-related injuries and those presenting with unintentional injuries, a
41 key focus of our previous research.^{93,94} Findings from such comparisons may assist health care
42 providers, particularly in the ED, to differentiate between physical elder abuse and unintentional
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3 injuries, informing future development of clinical algorithms to assist in this identification.
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5 Because we may have more controls than needed meeting the selection criteria within the first
6
7 control cohort outlined above, we will further conduct propensity score matching to select
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9 controls that more closely match with the cases.
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12 We recognize that older adults selected as control subjects may actually be victims of
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14 physical elder abuse. To minimize the likelihood of this, we will ensure that all selected controls
15
16 have never received any elder maltreatment-related diagnosis within Medicare claims data.
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19 20 21 *Focus on Physical Abuse* 22

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24 Though physical elder abuse may occur less frequently than other types of mistreatment,
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26 we think that focusing on these cases is a strength of our approach. Researchers have recognized
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28 that elder mistreatment is not a monolithic phenomenon and that etiologies, victim and
29
30 perpetrator characteristics, risk factors, clinical features, and sequelae likely differ in important
31
32 ways between mistreatment types.⁹⁵ This is an important reason that previous research has
33
34 yielded inconsistent findings and little clinically useful information is likely that heterogeneous
35
36 cases were analyzed together. We have chosen to focus on physical abuse because this violent
37
38 mistreatment may be particularly dangerous for an older adult. Our research focuses on health
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40 care utilization for abuse victims and the potential for improving early identification in health
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42 care settings such as the emergency department. Given that physical abuse often causes acute
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44 injury which may trigger health care visits more commonly than other types of elder
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46 mistreatment, health care providers may have a particular opportunity to identify it. Linking
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48 known elder abuse cases to Medicare claims data to describe rates and patterns of health care
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3 utilization may also be used to examine victims of other types of elder mistreatment, though, and
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5 we plan to explore this in the future.
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7 *Analysis*

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10 We will conduct descriptive longitudinal analysis of health care utilization up to 3 years
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12 before and 3 years after the detection of elder abuse (and among control cohorts). For each elder
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14 abuse case, we will determine the calendar month in which the case was detected (the “index
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16 month”). We will then group months before and after the index month into 3-month
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18 intervals/quarters. Our unit of analysis will be patient-quarter. We will plot measured outcomes
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20 over time (centered around the index month) and visualize level of utilization in time blocks in
21
22 relationship to the index month.
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26 We will compare utilization between physical elder abuse cases and non-victim control
27
28 subjects using the key measures described above, focusing on identifying important differences.
29
30 Comparisons will also specifically focus on rates of radiographic utilization of maxillofacial CT
31
32 scan and forearm x-rays as well as diagnoses including acute or chronic facial or chronic ulnar
33
34 fracture, and chronic rib fracture as they have been found to be potential predictors of physical
35
36 elder abuse.⁹⁶ We will compare total costs between cases and controls and then examine in detail
37
38 contributing costs associated with each type of utilization.
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42 We will also conduct statistical modelling of longitudinal healthcare utilization outcomes
43
44 to estimate adjusted differences between physical elder abuse victims and non-victims at various
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46 time points before and after the index month. For example, for the dichotomous outcome of any
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48 ED or inpatient admission in a quarter, we will estimate a mixed logistic regression where major
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50 covariates include victim status, time (relative to index month), and interaction of victim status
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52 and time, controlling for individual demographics and comorbidities. Random effects will be
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3 specified at the patient level (to account for repeated measures of the same individual) and zip
4 code (to account for clustering of patients within the same zip code) levels.
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8 We have conducted power calculations with these cases and controls, incorporating
9 assumptions about Medicare linking rate (50% of cases), number of quarters of data contributed
10 by each individual (6 quarters), percentage of subjects with ≥ 1 ED visit in a quarter (12% of elder
11 abuse victims and 6% of controls), and intra cluster correlation (0.2, to account for clustering of
12 quarters within the same individual). Using these assumptions, we have a power of 0.82, which
13 is adequate to identify important differences in utilization between cases and controls.
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24 *Using Machine Learning*

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26 The comparative statistical analysis described above will illuminate the trajectories of
27 health care use one type at a time. It lacks the ability to integrate multi-dimensional data that,
28 combined, forms unique patterns of care. Recent innovations in machine learning make it
29 possible to use vast amounts of data, such as service utilization, diagnoses received, and
30 procedures performed, to identify sequences and mix of clinical events likely to lead to particular
31 outcomes or suggestive of an underlying disease process for different cohorts of patients.⁹⁷⁻¹⁰²
32
33 For example, sequential pattern mining has been used in child abuse to examine patterns of
34 services provided to victims.^{103,104} To supplement the proposed statistical analysis, we propose to
35 search for features within claims data that may be suggestive that an older adult is a victim of
36 abuse. We will use Sequential PAttern Discovery using Equivalence classes (SPADE),¹⁰⁵ a well-
37 established algorithm which identifies patterns that are observed more than a user-defined
38 frequency threshold in a cohorts' sequences of event. In addition, we will use Markov
39 modeling¹⁰⁶ to identify the probabilities of observed patterns and associated underlying status of
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3 abuse to better distinguish patterns that are unique to elderly abused patients. We may find, for
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5 example, that a significant percentage of abuse victims have two ED visits and a hospitalization
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7 within a 3 month period and receive forearm x-rays and are diagnosed with a fracture, but this
8
9 pattern is never seen in controls.

11 12 *Discussion*

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14 This ongoing work will address a significant gap in current knowledge about elder abuse
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16 by improving understanding of how physical abuse victims use health care services differently
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18 than non-victims as well as associated costs. We anticipate insights from our findings will
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20 generate hypotheses that may be tested in future studies in different populations and among
21
22 victims of different types of elder mistreatment. We also expect that this work will lead to
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24 additional uses of claims data to explore the health consequences of elder abuse and to identify
25
26 utilization patterns with “red flags” suggestive of exposure. Ultimately, we anticipate that
27
28 knowledge gleaned will support the future development of a health informatics tool to identify
29
30 potential victims.
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34 35 *Limitations*

36
37 An important limitation of our approach is the use of legally adjudicated cases. Though
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39 using this source solves the important methodologic challenge of ensuring that case subjects are
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41 actually victims of abuse, legally adjudicated cases represent a small percentage of all cases, and
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43 abuse victims included may differ in important ways from other victims. They may have
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45 experienced more acute or severe abuse allowing identification, and subtle cases of abuse that
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47 are more challenging to detect may not have been included. Additionally, other circumstances
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49 surrounding the case including the availability of evidence, the willingness of the victim to
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51 participate, jurisdiction’s practice pattern may have impacted the decision to prosecute the
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53 perpetrator, significantly reducing potential generalizability. An important challenge in previous
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3 studies has been accurately classifying subjects as victims of mistreatment. This has likely
4 contributed to inconsistent research findings. Our new potential approach will generate
5 trustworthy results that may identify patterns and generate hypotheses that may be tested. We
6 anticipate that rigorous studies such as ours will lay the necessary groundwork for future studies
7 focused on identifying and examining more subtle cases.
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11 Also, our research strategy relies on linking to Medicare Fee-for-Service records. If
12 subjects were covered by Medicare Advantage or otherwise not covered by Medicare Fee-For-
13 Service for any period, information about their health care utilization would not be available
14 during that period. We have incorporated this potential into our power calculation assumptions,
15 however, and believe we will be able to identify important differences in utilization.
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19 Another limitation is that selected control subjects may actually be unidentified cases,
20 reducing the accuracy of our conclusions. Although we believe that machine learning techniques
21 have enormous potential to find subtle patterns, it is possible that we will not identify any that
22 are clinically identifiable or meaningful. Despite these potential limitations, we believe this
23 research offers a unique opportunity to use a large series of well-characterized cases of physical
24 elder abuse to help us understand the health-related markers that can be used to more validly
25 predict elder abuse, and thereby prevent it.
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28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 *Conclusion* 43

44 Improved understanding of patterns and associated costs of health care utilization among
45 elder abuse victims, which likely differs substantially from that of other older adults, is
46 potentially very valuable. It may improve the ability of health care providers to identify,
47 intervene, and prevent victimization. Further, it may inform policy changes to reduce costs and
48 help this vulnerable population. The research described here represents an important step in
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3 exploring the potential of examining health care utilization to provide insight into elder abuse
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5 and how to address it.
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For peer review only

Ethics and Dissemination

This project has been reviewed and approved by the Weill Cornell Medicine Institutional Review Board, protocol #1807019417, with initial approval on August 1, 2018. We aim to disseminate our results in peer-reviewed journals, at national and international conferences and among interested patient groups and the public.

Patient and public involvement

We plan to involve older adults including victims of elder mistreatment in the reporting and dissemination for this this research.

References

1. Acierno R, Hernandez MA, Amstadter AB, et al. Prevalence and correlates of emotional, physical, sexual, and financial abuse and potential neglect in the United States: the National Elder Mistreatment Study. *Am J Public Health* 2010;100:292-7.
2. Lachs MS, Pillemer K. Elder abuse. *Lancet* 2004;364:1263-72.
3. Under the Radar: New York State Elder Abuse Prevalence Study: Self-Reported Prevalence and Documented Case Surveys 2012. (Accessed February 10, 2020, at <https://ocfs.ny.gov/main/reports/Under%20the%20Radar%2005%2012%2011%20final%20report.pdf>)
4. National Research Council. Elder mistreatment: Abuse, neglect and exploitation in an aging America. Washington, DC: The National Academies Press; 2003.
5. National Center for Elder Abuse. The Elder Justice Roadmap: A Stakeholder Initiative to Respond to an Emerging Health, Justice, Financial, and Social Crisis. (Accessed February 10, 2020, at <https://www.justice.gov/file/852856/download>)
6. Lachs MS, Pillemer KA. Elder abuse. *N Engl J Med* 2015;373:1947-56.
7. Schofield MJ, Powers JR, Loxton D. Mortality and disability outcomes of self-reported elder abuse: a 12-year prospective investigation. *J Am Geriatr Soc* 2013;61:679-85.
8. Dyer CB, Pavlik VN, Murphy KP, Hyman DJ. The high prevalence of depression and dementia in elder abuse or neglect. *J Am Geriatr Soc* 2000;48:205-8.
9. Lachs MS, Williams CS, O'Brien S, Pillemer KA, Charlson ME. The mortality of elder mistreatment. *JAMA* 1998;280:428-32.
10. Dong XQ, Simon MA, Beck TT, et al. Elder abuse and mortality: the role of psychological and social wellbeing. *Gerontology* 2011;57:549-58.

- 1
2
3 11. Baker MW, LaCroix AZ, Wu C, Cochrane BB, Wallace R, Woods NF. Mortality risk
4 associated with physical and verbal abuse in women aged 50 to 79. *J Am Geriatr Soc*
5
6 2009;57:1799-809.
7
- 8
9
10 12. Pillemer K, Finkelhor D. The prevalence of elder abuse: a random sample survey.
11
12 *Gerontologist* 1988;28:51-7.
13
- 14 13. Murphy K, Waa S, Jaffer H, Sauter A, Chan A. A literature review of findings in physical
15
16 elder abuse. *Can Assoc Radiol J* 2013;64:10-4.
17
- 18 14. Lachs MS, Williams CS, O'Brien S, et al. ED use by older victims of family violence. *Ann*
19
20 *Emerg Med* 1997;30:448-54.
21
- 22 15. Bond MC, Butler KH. Elder abuse and neglect: definitions, epidemiology, and approaches
23
24 to emergency department screening. *Clin Geriatr Med* 2013;29:257-73.
25
- 26 16. Geroff AJ, Olshaker JS. Elder abuse. *Emerg Med Clin North Am* 2006;24:491-505.
27
- 28 17. Dong X, Simon MA. Association between elder abuse and use of ED: findings from the
29
30 Chicago Health and Aging Project. *Am J Emerg Med* 2013;31:693-8.
31
- 32 18. Friedman LS, Avila S, Tanouye K, Joseph K. A case-control study of severe physical abuse
33
34 of older adults. *J Am Geriatr Soc* 2011;59:417-22.
35
- 36 19. Heyborne RD. Elder abuse: keeping the unthinkable in the differential. *Acad Emerg Med*
37
38 2007;14:566-7.
39
- 40 20. Chan KL, Choi WM, Fong DY, Chow CB, Leung M, Ip P. Characteristics of family
41
42 violence victims presenting to emergency departments in Hong Kong. *J Emerg Med*
43
44 2013;44:249-58.
45
- 46 21. Dong X, Simon MA. Elder abuse as a risk factor for hospitalization in older persons. *JAMA*
47
48 *Intern Med* 2013;173:911-7.
49
50
51
52
53
54
55
56
57
58
59
60

- 1
 - 2
 - 3
 - 4
 - 5
 - 6
 - 7
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 - 46
 - 47
 - 48
 - 49
 - 50
 - 51
 - 52
 - 53
 - 54
 - 55
 - 56
 - 57
 - 58
 - 59
 - 60
22. Lachs MS, Williams CS, O'Brien S, Pillemer KA. Adult protective service use and nursing home placement. *Gerontologist* 2002;42:734-9.
23. Dong X, Simon MA. Association between reported elder abuse and rates of admission to skilled nursing facilities: findings from a longitudinal population-based cohort study. *Gerontology* 2013;59:464-72.
24. Mouton CP, Rodabough RJ, Rovi SL, et al. Prevalence and 3-year incidence of abuse among postmenopausal women. *Am J Public Health* 2004;94:605-12.
25. Jackson AM, Deye KP, Halley T, et al. Curiosity and critical thinking: identifying child abuse before it is too late. *Clin Pediatr* 2015;54:54-61.
26. Jenny C, Hymel KP, Ritzen A, Reinert SE, Hay TC. Analysis of missed cases of abusive head trauma. *JAMA* 1999;281:621-6.
27. King WK, Kiesel EL, Simon HK. Child abuse fatalities: are we missing opportunities for intervention? *Pediatr Emerg Care* 2006;22:211-4.
28. Letson MM, Cooper JN, Deans KJ, et al. Prior opportunities to identify abuse in children with abusive head trauma. *Child Abuse Negl* 2016;60:36-45.
29. Ravichandiran N, Schuh S, Bejuk M, et al. Delayed identification of pediatric abuse-related fractures. *Pediatrics* 2010;125:60-6.
30. Thorpe EL, Zuckerbraun NS, Wolford JE, Berger RP. Missed opportunities to diagnose child physical abuse. *Pediatr Emerg Care* 2014;30:771-6.
31. Kothari CL, Rhodes KV. Missed opportunities: emergency department visits by police-identified victims of intimate partner violence. *Ann Emerg Med* 2006;47:190-9.
32. Willson P, Cesario S, Fredland N, et al. Primary healthcare provider's lost opportunity to help abused women. *J Am Acad Nurse Pract* 2001;13:565-70.

- 1
- 2
- 3 33. Lindberg DM, Beaty B, Juarez-Colunga E, Wood JN, Runyan DK. Testing for abuse in
- 4 children with sentinel injuries. *Pediatrics* 2015;136:831-8.
- 5
- 6
- 7
- 8 34. Sheets LK, Leach ME, Koszewski IJ, Lessmeier AM, Nugent M, Simpson P. Sentinel
- 9 injuries in infants evaluated for child physical abuse. *Pediatrics* 2013;131:701-7.
- 10
- 11
- 12 35. Brown DS, Fang X, Florence CS. Medical costs attributable to child maltreatment a
- 13 systematic review of short- and long-term effects. *Am J Prev Med* 2011;41:627-35.
- 14
- 15
- 16
- 17 36. Rovi S, Chen PH, Johnson MS. The economic burden of hospitalizations associated with
- 18 child abuse and neglect. *Am J Public Health* 2004;94:586-90.
- 19
- 20
- 21 37. Florence C, Brown DS, Fang X, Thompson HF. Health care costs associated with child
- 22 maltreatment: impact on medicaid. *Pediatrics* 2013;132:312-8.
- 23
- 24
- 25
- 26 38. Jones AS, Dienemann J, Schollenberger J, et al. Long-term costs of intimate partner
- 27 violence in a sample of female HMO enrollees. *Womens Health Issues* 2006;16:252-61.
- 28
- 29
- 30 39. Peterson C, Xu L, Florence C, et al. The medical cost of abusive head trauma in the United
- 31 States. *Pediatrics* 2014;134:91-9.
- 32
- 33
- 34
- 35 40. Miller TR, Steinbeigle R, Lawrence BA, et al. Lifetime cost of abusive head trauma at ages
- 36 0-4, USA. *Prev Sci* 2017.
- 37
- 38
- 39
- 40 41. Fang X, Brown DS, Florence CS, Mercy JA. The economic burden of child maltreatment in
- 41 the United States and implications for prevention. *Child Abuse Negl* 2012;36:156-65.
- 42
- 43
- 44 42. Max W, Rice DP, Finkelstein E, Bardwell RA, Leadbetter S. The economic toll of intimate
- 45 partner violence against women in the United States. *Violence Vict* 2004;19:259-72.
- 46
- 47
- 48
- 49 43. Thielen FW, Ten Have M, de Graaf R, et al. Long-term economic consequences of child
- 50 maltreatment: a population-based study. *Eur Child Adolesc Psychiatry* 2016;25:1297-305.
- 51
- 52
- 53
- 54
- 55
- 56
- 57
- 58
- 59
- 60

- 1
2
3 44. Yang J, Miller TR, Zhang N, LeHew B, Peek-Asa C. Incidence and cost of sexual violence
4
5 in Iowa. *Am J Prev Med* 2014;47:198-202.
6
- 7
8 45. Teresi JA, Burnes D, Skowron EA, et al. State of the science on prevention of elder abuse
9
10 and lessons learned from child abuse and domestic violence prevention: Toward a
11
12 conceptual framework for research. *J Elder Abuse Negl* 2016;28:263-300.
13
- 14
15 46. McCall N. Centers for Medicare and Medicaid Services. Investigation of Increasing Rates of
16
17 Hospitalization for Ambulatory Care Sensitive Conditions Among Medicare Fee-for-Service
18
19 Beneficiaries. (Accessed on February 10, 2020, at: [https://www.cms.gov/Research-](https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/Reports/Downloads/McCall_2004_3.pdf)
20
21 [Statistics-Data-and-Systems/Statistics-Trends-and-](https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/Reports/Downloads/McCall_2004_3.pdf)
22
23 [Reports/Reports/Downloads/McCall_2004_3.pdf](https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/Reports/Downloads/McCall_2004_3.pdf))
24
25
- 26
27 47. Merrick ES, Hodgkin D, Garnick DW, et al. Older adults' inpatient and emergency
28
29 department utilization for ambulatory-care-sensitive conditions: relationship with alcohol
30
31 consumption. *J Aging Health* 2011;23:86-111.
32
- 33
34 48. Brownell J, Wang J, Smith A, Stephens C, Hsia RY. Trends in emergency department visits
35
36 for ambulatory care sensitive conditions by elderly nursing home residents, 2001 to 2010.
37
38 *JAMA Intern Med* 2014;174:156-8.
39
- 40
41 49. Carter MW, Datti B, Winters JM. ED visits by older adults for ambulatory care-sensitive
42
43 and supply-sensitive conditions. *Am J Emerg Med* 2006;24:428-34.
44
- 45
46 50. Duseja R, Bardach NS, Lin GA, et al. Revisit rates and associated costs after an emergency
47
48 department encounter: a multistate analysis. *Ann Intern Med* 2015;162:750-6.
49
- 50
51 51. Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the Medicare
52
53 fee-for-service program. *N Engl J Med* 2009;360:1418-28.
54
55
56
57
58
59
60

- 1
- 2
- 3 52. Liu SW, Obermeyer Z, Chang Y, Shankar KN. Frequency of ED revisits and death among
- 4
- 5 older adults after a fall. *Am J Emerg Med* 2015;33:1012-8.
- 6
- 7
- 8 53. Vashi AA, Fox JP, Carr BG, et al. Use of hospital-based acute care among patients recently
- 9
- 10 discharged from the hospital. *JAMA* 2013;309:364-71.
- 11
- 12
- 13 54. Ahmad M, Lachs MS. Elder abuse and neglect: what physicians can and should do. *Clev*
- 14
- 15 *Clin J Med* 2002;69:801-8.
- 16
- 17 55. Rosen T, Stern ME, Elman A, Mulcare MR. Identifying and initiating intervention for elder
- 18
- 19 abuse and neglect in the Emergency Department. *Clin Geriatr Med* 2018;34:435-51.
- 20
- 21
- 22 56. Friedlaender EY, Rubin DM, Alpern ER, Mandell DS, Christian CW, Alessandrini EA.
- 23
- 24 Patterns of health care use that may identify young children who are at risk for
- 25
- 26 maltreatment. *Pediatrics* 2005;116:1303-8.
- 27
- 28
- 29 57. Merrick EL, Hodgkin D, Garnick DW, et al. Unhealthy drinking patterns and receipt of
- 30
- 31 preventive medical services by older adults. *J Gen Intern Med* 2008;23:1741-8.
- 32
- 33
- 34 58. Asch SM, Sloss EM, Hogan C, Brook RH, Kravitz RL. Measuring underuse of necessary
- 35
- 36 care among elderly Medicare beneficiaries using inpatient and outpatient claims. *JAMA*
- 37
- 38 2000;284:2325-33.
- 39
- 40
- 41 59. Klabunde CN, Meissner HI, Wooten KG, Breen N, Singleton JA. Comparing colorectal
- 42
- 43 cancer screening and immunization status in older americans. *Am J Prev Med* 2007;33:1-8.
- 44
- 45 60. Ozminkowski RJ, Goetzel RZ, Shechter D, Stapleton DC, Baser O, Lapin P. Predictors of
- 46
- 47 preventive service use among Medicare beneficiaries. *Health Care Financ Rev* 2006;27:5-
- 48
- 49 23.
- 50
- 51
- 52
- 53
- 54
- 55
- 56
- 57
- 58
- 59
- 60

- 1
2
3 61. Scott TL, Gazmararian JA, Williams MV, Baker DW. Health literacy and preventive health
4 care use among Medicare enrollees in a managed care organization. *Med Care* 2002;40:395-
5 404.
6
7
- 8
9
10 62. Colligan EM, Pines JM, Colantuoni E, Wolff JL. Factors Associated With Frequent
11 Emergency Department Use in the Medicare Population. *Medical Care Res Rev*
12 2017;73:311-327.
13
14
- 15 63. Bice TW, Boxerman SB. A quantitative measure of continuity of care. *Med Care*
16 1977;15:347-9.
17
18
- 19 64. Jha AK, Aubert RE, Yao J, Teagarden JR, Epstein RS. Greater adherence to diabetes drugs
20 is linked to less hospital use and could save nearly \$5 billion annually. *Health Aff*
21 (Millwood) 2012;31:1836-46.
22
23
- 24 65. Roebuck MC, Liberman JN, Gemmill-Toyama M, Brennan TA. Medication adherence leads
25 to lower health care use and costs despite increased drug spending. *Health Aff (Millwood)*
26 2011;30:91-9.
27
28
- 29 66. Mues KE, Liede A, Liu J, et al. Use of the Medicare database in epidemiologic and health
30 services research: a valuable source of real-world evidence on the older and disabled
31 populations in the US. *Clin Epidemiol* 2017;9:267-77.
32
33
- 34 67. Chen J, Hsieh AF, Dharmarajan K, Masoudi FA, Krumholz HM. National trends in heart
35 failure hospitalization after acute myocardial infarction for Medicare beneficiaries: 1998-
36 2010. *Circulation* 2013;128:2577-84.
37
38
- 39 68. Fitch K, Pelizzari PM, Pyenson B. Inpatient Utilization and Costs for Medicare Fee-for-
40 Service Beneficiaries with Heart Failure. *Am Health Drug Benefits* 2016;9:96-104.
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3 69. Genao L, Durheim MT, Mi X, Todd JL, Whitson HE, Curtis LH. Early and Long-term
4 Outcomes of Older Adults after Acute Care Encounters for Chronic Obstructive Pulmonary
5 Disease Exacerbation. *Ann Am Thorac Soc* 2015;12:1805-12.
6
7
8
9
10 70. Wetmore JB, Peng Y, Jackson S, Matlon TJ, Collins AJ, Gilbertson DT. Patient
11 characteristics, disease burden, and medication use in stage 4 - 5 chronic kidney disease
12 patients. *Clin Nephrol* 2016;85:101-11.
13
14
15
16
17 71. Baicker K, Chandra A, Skinner JS, Wennberg JE. Who you are and where you live: how
18 race and geography affect the treatment of medicare beneficiaries. *Health Aff*
19 (Millwood):VAR33-44.
20
21
22
23
24 72. Joynt KE, Orav EJ, Jha AK. Thirty-day readmission rates for Medicare beneficiaries by race
25 and site of care. *JAMA* 2011;305:675-81.
26
27
28
29 73. Merrick EL, Horgan CM, Hodgkin D, et al. Unhealthy drinking patterns in older adults:
30 prevalence and associated characteristics. *J Am Geriatr Soc* 2008;56:214-23.
31
32
33 74. Colligan EM, Pines JM, Colantuoni E, Howell B, Wolff JL. Risk Factors for Persistent
34 Frequent Emergency Department Use in Medicare Beneficiaries. *Ann Emerg Med*
35 2016;67:721-9.
36
37
38
39
40 75. Phongtankuel V, Johnson P, Reid MC, et al. Risk factors for hospitalization of home
41 hospice enrollees. *Am J Hosp Palliat Care* 2016:1049909116659439.
42
43
44
45 76. ResDAC Research Data Assistance Center. Data Availability. (Accessed on February 10,
46 2020 at <https://www.resdac.org/cms-data/file-availability>.)
47
48
49 77. Annest JL, Fingerhut LA, Gallagher SS, et al. Strategies to improve external cause-of-injury
50 coding in state-based hospital discharge and emergency department data systems:
51
52
53
54
55
56
57
58
59
60

- 1
2
3 recommendations of the CDC Workgroup for Improvement of External Cause-of-Injury
4 Coding. *MMWR Recomm Rep* 2008;57:1-15.
5
6
7
8 78. Coben JH, Steiner CA, Barrett M, Merrill CT, Adamson D. Completeness of cause of injury
9 coding in healthcare administrative databases in the United States, 2001. *Inj Prev*
10 2006;12:199-201.
11
12
13
14 79. Spivey MI, Schnitzer PG, Kruse RL, Slusher P, Jaffe DM. Association of injury visits in
15 children and child maltreatment reports. *J Emerg Med* 2009;36:207-14.
16
17
18
19 80. LaCalle E, Rabin E. Frequent users of emergency departments: the myths, the data, and the
20 policy implications. *Ann Emerg Med* 2010;56:42-8.
21
22
23
24 81. Locker TE, Baston S, Mason SM, Nicholl J. Defining frequent use of an urban emergency
25 department. *Emerg Med J* 2007;24:398-401.
26
27
28
29 82. Davis JW, Fujimoto RY, Chan H, Juarez DT. Identifying characteristics of patients with low
30 urgency emergency department visits in a managed care setting. *Manag Care* 2010;19:38-
31 44.
32
33
34
35 83. Uscher-Pines L, Pines J, Kellermann A, Gillen E, Mehrotra A. Emergency department visits
36 for nonurgent conditions: systematic literature review. *Am J Manag Care* 2013;19:47-59.
37
38
39
40 84. Bayliss EA, Ellis JL, Shoup JA, Zeng C, McQuillan DB, Steiner JF. Effect of continuity of
41 care on hospital utilization for seniors with multiple medical conditions in an integrated
42 health care system. *Ann Fam Med* 2015;13:123-9.
43
44
45
46
47 85. Liss DT, Chubak J, Anderson ML, Saunders KW, Tuzzio L, Reid RJ. Patient-reported care
48 coordination: associations with primary care continuity and specialty care use. *Ann Fam*
49 *Med* 2011;9:323-9.
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3 86. Hess LM, Raebel MA, Conner DA, Malone DC. Measurement of adherence in pharmacy
4 administrative databases: a proposal for standard definitions and preferred measures. *Ann*
5
6 *Pharmacother* 2006;40:1280-88.
7
8
9
10 87. Karve S, Cleves MA, Helm M, Hudson TJ, West DS, Martin BC. Good and poor adherence:
11 optimal cut-point for adherence measures using administrative claims data. *Curr Med Res*
12
13 *Opin* 2009;25:2303-10.
14
15
16
17 88. Colantonio LD, Huang L, Monda KL, et al. Adherence to High-Intensity Statins Following
18 a Myocardial Infarction Hospitalization Among Medicare Beneficiaries. *JAMA Cardiol*
19
20 2017;2:890-5.
21
22
23
24 89. Ostbye T, Taylor DH, Jr., Clipp EC, Scoyoc LV, Plassman BL. Identification of dementia:
25 agreement among national survey data, medicare claims, and death certificates. *Health Serv*
26
27 *Res* 2008;43:313-26.
28
29
30
31 90. Taylor DH, Jr., Fillenbaum GG, Ezell ME. The accuracy of medicare claims data in
32 identifying Alzheimer's disease. *J Clin Epidemiol* 2002;55:929-37.
33
34
35
36 91. Faurot KR, Jonsson Funk M, Pate V, et al. Using claims data to predict dependency in
37 activities of daily living as a proxy for frailty. *Pharmacoepidemiol Drug Saf* 2015;24:59-66.
38
39
40 92. Zhang HT, McGrath LJ, Wyss R, Ellis AR, Sturmer T. Controlling confounding by frailty
41 when estimating influenza vaccine effectiveness using predictors of dependency in activities
42 of daily living. *Pharmacoepidemiol Drug Saf* 2017.
43
44
45
46 93. Rosen T, Bloemen EM, LoFaso VM, Clark S, Flomenbaum NE, Lachs MS. Emergency
47 Department presentations for injuries in older adults independently known to be victims of
48 elder abuse. *J Emerg Med* 2016;50:518-26.
49
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3 94. Rosen T, LoFaso V, Bloemen EM, et al. Injury patterns in physical elder abuse: preliminary
4 findings from a pilot sample of highly adjudicated cases. Society of Academic Emergency
5 Medicine Annual Scientific Meeting. San Diego 2015.
6
7
8
9
10 95. Jackson, S. Understanding elder abuse: new directions for developing theories of elder
11 abuse occurring in domestic settings. 2013. (Accessed on February 10, 2020, at
12 <https://www.ncjrs.gov/pdffiles1/nij/241731.pdf>)
13
14
15
16
17 96. Wong NZ, Rosen T, Sanchez AM, et al. Imaging findings in elder abuse: a role for
18 radiologists in detection. *Can Assoc Radiol J* 2017;68:16-20.
19
20
21 97. Zhang Y, Padman R. Paving the COWPath: Learning and Visualizing Clinical Pathways
22 from Electronic Health Record Data. Carnegie Mellon University; 2015.
23
24
25
26 98. Movahedi F, Carey L, Zhang Y, Padman R, Antaki J. Care pathway after Left Ventricular
27 Assist Devices (LVAD) implementation. International Society for Heart and Lung
28 Transplantation. San Diego, CA 2017.
29
30
31
32
33 99. Ghosh S, Li J, Cao L, Ramamohanarao K. Septic shock prediction for ICU patients via
34 coupled HMM walking on sequential contrast patterns. *J Biomed Inform* 2017;66:19-31.
35
36
37
38 100. Kawamoto R, Nazir A, Kameyama A, et al. Hidden Markov model for analyzing time-series
39 health checkup data. *Stud Health Technol Inform* 2013;192:491-5.
40
41
42
43 101. Watkins RE, Eagleson S, Veenendaal B, Wright G, Plant AJ. Disease surveillance using a
44 hidden Markov model. *BMC Med Inform Decis Mak* 2009;9:39.
45
46
47 102. Zhang Y, Padman R. Innovations in chronic care delivery using data-driven clinical
48 pathways. *Am J Manag Care* 2015;21:e661-8.
49
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3 103. Duncan DF, Kum HC, Weigensberg EC, Flair KA, Stewart CJ. Informing child welfare
4 policy and practice: Using knowledge discovery and data mining technology via a dynamic
5 web site. *Child Maltreat* 2008;13:383-91.
6
7
8
9
10 104. Hye-Chung (Monica) Kum JP, Wei Wang, Dean Duncan. ApproxMAP: Approximate
11 Mining of Consensus Sequential Patterns. (Accessed on February 10, 2020 at
12 <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.12.2633&rep=rep1&type=pdf>)
13
14
15
16
17 105. Zaki MJ. SPADE: An Efficient Algorithm for Mining Frequent Sequences. *Machine*
18 *Learning* 2001;42:31-60.
19
20
21 106. Rabiner L. A tutorial on hidden Markov models and selected applications in speech
22 recognition. *IEEE* 1989. (Accessed on February 10, 2020 at
23 [http://www.ece.ucsb.edu/Faculty/Rabiner/ece259/Reprints/tutorial%20on%20hmm%20and](http://www.ece.ucsb.edu/Faculty/Rabiner/ece259/Reprints/tutorial%20on%20hmm%20and%20applications.pdf)
24 [%20and](http://www.ece.ucsb.edu/Faculty/Rabiner/ece259/Reprints/tutorial%20on%20hmm%20and%20applications.pdf)
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5 contributed to and approved the final manuscript.
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Figure 1: Conceptual Framework for Health Care Utilization by Elder Abuse Victims

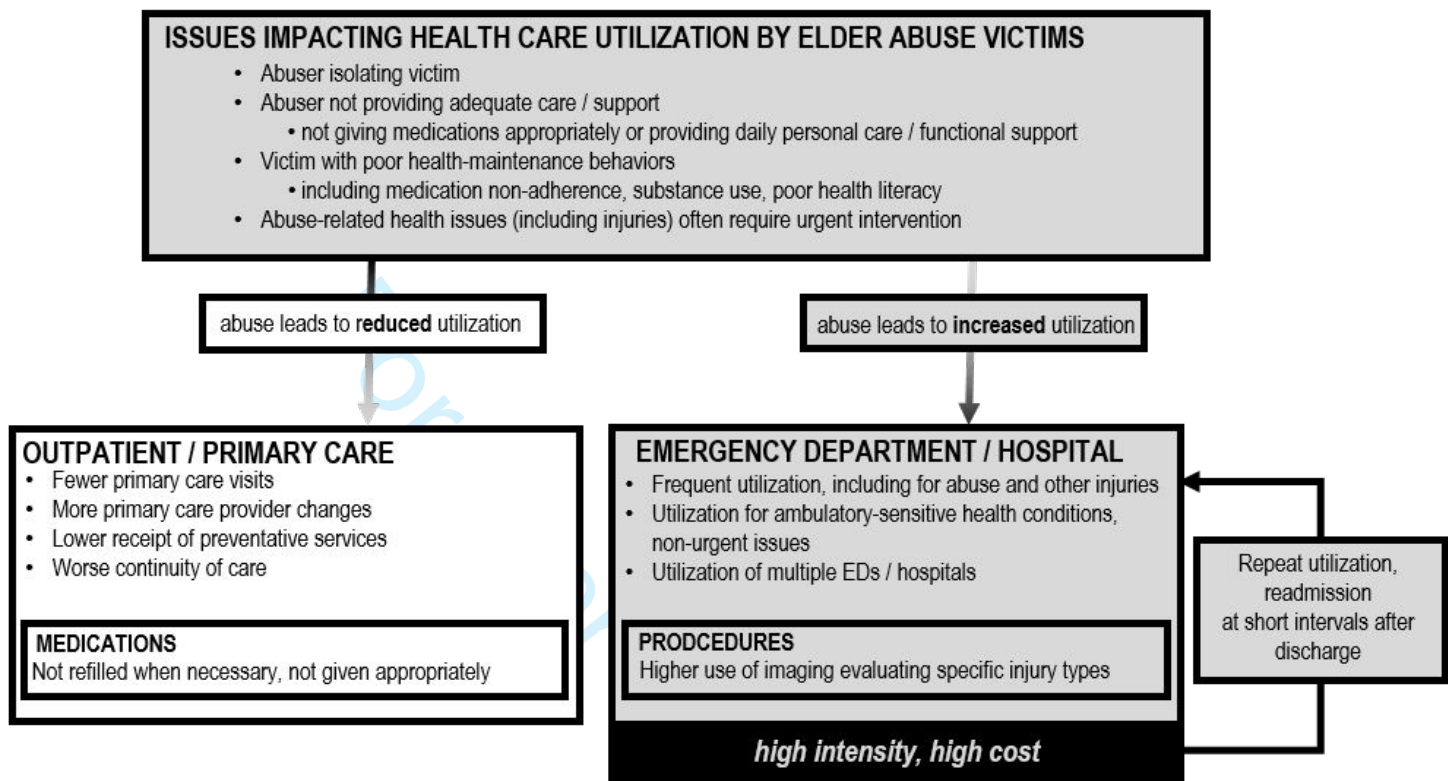


Table 1: Selected Key Measures of Health Care Utilization

Site / Type	Utilization Measure
Emergency Department	<ul style="list-style-type: none"> • Injury-related visits • Total visits, including identification of high-frequency users • Low urgency visits, visits for ambulatory care sensitive conditions • Repeat visits to the ED within 3 days, 7 days, 30 days of initial visit • Visits to multiple EDs
Hospital	<ul style="list-style-type: none"> • Injury-related hospitalizations • Total hospitalizations • Visits for ambulatory care sensitive conditions • Repeat hospitalizations within 30 days, 90 days of initial hospitalization • Visits to multiple hospitals
Outpatient	<ul style="list-style-type: none"> • Injury-related visits to primary care provider • Total visits to primary care provider • Receipt of preventative services • Periods with no primary care provider selected • Changes to primary care provider • Continuity of care (via Continuity of Care Index) • Medication adherence (via Proportion of Days Covered)

BMJ Open

Identifying Patterns of Health Care Utilization among Physical Elder Abuse Victims Using Medicare Data and Legally Adjudicated Cases: Protocol for Case-Control Study using Data Linkage and Machine Learning

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24 **Identifying Patterns of Health Care Utilization among Physical Elder Abuse Victims Using**
25 **Medicare Data and Legally Adjudicated Cases: Protocol for Case-Control Study using**
26 **Data Linkage and Machine Learning**
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Abstract

Introduction: Physical elder abuse is common and has serious health consequences but is under-recognized and under-reported. As assessment by health care providers may represent the only contact outside family for many older adults, clinicians have a unique opportunity to identify suspected abuse and initiate intervention. Preliminary research suggests elder abuse victims may have different patterns of health care utilization than other older adults, with increased rates of Emergency Department use, hospitalization, and nursing home placement. Little is known, however, about the patterns of this increased utilization and associated costs. To help fill this gap, we describe here the protocol for a study exploring patterns of health care utilization and associated costs for known physical elder abuse victims compared to non-victims.

Methods and Analysis: We hypothesize that various aspects of health care utilization are differentially affected by physical elder abuse victimization, increasing ED/hospital utilization and reducing outpatient/primary care utilization. We will obtain Medicare claims data for a series of well-characterized, legally adjudicated cases of physical elder abuse to examine victims' health care utilization before and after the date of abuse detection. We will also compare these physical elder abuse victims to a matched comparison group of non-victimized older adults using Medicare claims. We will use machine learning approaches to extend our ability to identify patterns suggestive of potential physical elder abuse exposure. Describing unique patterns and associated costs of health care utilization among elder abuse victims may improve the ability of health care providers to identify and, ultimately, intervene and prevent victimization.

Ethics and Dissemination: This project has been reviewed and approved by the Weill Cornell Medicine Institutional Review Board, protocol #1807019417, with initial approval on August 1,

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2018. We aim to disseminate our results in peer-reviewed journals, at national and international conferences and among interested patient groups and the public.

Keywords: elder abuse; elder mistreatment; health care utilization; machine learning; research protocol

For peer review only

Article Summary: Strengths and limitations of this study:

- We explore patterns of health care utilization and associated costs for known physical elder abuse victims, about common and serious phenomenon about which little is known
- We use Medicare claims data for a series of well-characterized, legally adjudicated cases of physical elder abuse to comprehensively examine victims' health care utilization before and after the date of abuse detection in comparison to non-victimized older adults algorithmically selected from Medicare claims
- We use machine learning approaches to better identify patterns suggestive of potential physical elder abuse exposure
- Though using legally adjudicated cases solves the important methodologic challenge of ensuring that case subjects are actually victims of abuse, these cases represent a small percentage of all elder abuse cases and their experience of abuse may differ in important ways from other victims
- Subjects must have been enrolled in Medicare Fee-for-Service rather than Medicare Advantage or another insurance for us to be able to examine their health care utilization

Introduction

Elder abuse is common and has serious health consequences but is under-recognized and under-reported. As many as 10% of US older adults experience elder abuse each year.¹⁻⁶ This maltreatment may include physical abuse, sexual abuse, neglect, psychological abuse, or financial exploitation, and many victims suffer from multiple types of abuse concurrently.¹⁻⁵ Evidence suggests that elder abuse is associated with adverse health outcomes, including disability,⁷ dementia,⁸ depression,⁸ and mortality.⁹⁻¹¹ Despite its frequency, many elder abuse victims endure it for years before having it discovered or dying. Studies suggest that as few as 1 in 24 cases of elder abuse is reported to the authorities,^{1,3,12} and some of the associated morbidity and mortality is likely due to this delay in identification and intervention.¹³

As assessment by health care providers may represent the only outside contact for many older adults, so clinicians have a unique opportunity to identify suspected elder abuse and initiate intervention.¹⁴⁻²⁰ Elder abuse victims have increased rates of emergency department (ED) use,^{14,17} hospitalization,²¹ and nursing home placement.^{22,23} Little is known, however, about the patterns of this increased utilization and associated costs.^{5,24} Influential research in child abuse²⁵⁻³⁰ and intimate partner violence^{31,32} has focused on health care utilization before identification, highlighting that many victims had multiple previous visits for likely abuse-related issues, suggesting “missed opportunities” for identification and early intervention. Child abuse researchers have found that minor abusive injuries, “sentinel injuries,” are commonly found in children who are subsequently victims of severe child abuse but rare in those who aren’t.^{33,34} Strategies are being developed to capitalize on these findings to prevent morbidity and mortality for victims. Additionally, research has found that health care costs were significantly higher for victims of child abuse and intimate partner violence both in the short-term^{35,36} and long-term,^{35,37-40} compared to costs incurred by non-victims. These increased costs represent a key

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3 component of the overall economic burden of these phenomena,⁴¹⁻⁴⁴ and related research
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5 findings have been critical in revealing the scope and impact of child abuse and intimate partner
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7 violence and in driving policymaking decisions. We know of no analogous research in elder
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9 abuse.
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12 To help fill this gap in the literature, we describe here the protocol for a study designed to
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14 explore in detail patterns of health care utilization and associated costs for known physical elder
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16 abuse victims compared to non-victims using analytic techniques including machine learning.
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Methods and Analysis

Conceptual Framework and Hypotheses

We hypothesize that various aspects of health care utilization are differentially affected by physical elder abuse victimization. Many issues related to physical elder abuse potentially increase ED/hospital utilization and reduce outpatient/primary care utilization. We have developed a conceptual framework (Figure 1) to explain this pattern. This framework is informed by a model for elder abuse research that members of our team developed as part of the National Institute on Aging (NIA) Workshop “Multiple Approaches to Understanding and Preventing Elder Abuse and Mistreatment: Prevention and Intervention.”⁴⁵

As shown in Figure 1, we further hypothesize that physical elder abuse victims, due to their poor connection to primary care, will have increased utilization of EDs/hospitals for ambulatory care-sensitive conditions (ACSCs) and for non-urgent issues. ACSCs are conditions that, if treated in a timely fashion with adequate primary care and managed properly on an outpatient basis, should not advance to the point where an ED visit or hospitalization is required.⁴⁶ Measuring the rate of use of high intensity, high cost services to treat these conditions is common in health services research to assess access to and quality of primary care.⁴⁶⁻⁴⁹ Similarly, use of the ED for non-urgent issues suggests inappropriate use in the absence of primary care.

We also hypothesize that physical elder abuse victims will have high rates of repeat ED visits and re-hospitalizations within short intervals. This results from poor connections to primary care and poor adherence to outpatient follow-up care recommendations.⁵⁰⁻⁵³ We anticipate that physical elder abuse victims will also have higher use of the ED/hospital for issues directly related to abuse, including presentation for injuries and use of imaging to evaluate

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3 specific injury types. Based on anecdotal experiences by elder abuse experts,⁵⁴ we also
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5 hypothesize that, compared to other older adults, physical elder abuse victims will more likely be
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7 seen at multiple EDs and hospitals. This “hospital hopping” often occurs to avoid abuse
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9 detection.⁵⁵
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12 Conversely, we hypothesize that poor access to and less frequent use of primary care will
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14 be associated with more primary care provider changes, lower receipt of preventative services,
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16 and worse continuity of care. More frequent changes in primary care providers result in fractured
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18 care and have been shown in previous claims-based research to be associated with child abuse.⁵⁶
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20 Receipt of preventative services has been used in previous studies to assess level of primary care
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22 utilization among Medicare beneficiaries and has been shown to be lower in older adults with
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24 low primary care access including excess alcohol use and poor health literacy.⁵⁷⁻⁶¹ We anticipate
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26 that physical elder abuse victims will have lower continuity of care, which has been shown in
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28 Medicare beneficiaries to be associated with increased rates of frequent ED use.⁶² Continuity of
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30 care assesses the dispersion of outpatient evaluation and management visits, examining how
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32 many unique doctors a patient visits within a specific timeframe.⁶³
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37 And finally, we also hypothesize that victims of physical elder abuse, partially due to
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39 poor connection to primary care, will have poorer adherence to medications for chronic
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41 conditions, such as diabetes medications and anti-hypertensives, which has been shown to impact
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43 high intensity healthcare utilization and cost.^{64,65}
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49 *Study Design*

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51 In this retrospective study, we will obtain Medicare claims data for a series of legally
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53 adjudicated cases of physical elder abuse to comprehensively examine victims’ health care
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3 utilization before and after the date of abuse detection. We will also compare physical elder
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5 abuse victims to other non-victimized older adults. We will algorithmically select this
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7 comparison group from Medicare claims data to be matched to the physical elder abuse victims.
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10 We will compare victims' ED/hospital and outpatient primary care utilization to that of
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12 the control groups. We will use machine learning approaches to extend our ability to identify
13
14 patterns suggestive of potential physical elder abuse exposure.
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17 This project has been reviewed and approved by the Weill Cornell Medicine Institutional
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19 Review Board, protocol #1807019417 (initially approved on August 1, 2018). The Institutional
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21 Review Board approved waiving the requirement to obtain informed consent from subjects in
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23 this retrospective study.
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28 *Study Subjects*

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30 For this research, we plan to use a well-characterized series of 204 legally adjudicated
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32 cases of physical elder abuse from Brooklyn, New York and Seattle, Washington. The
33
34 methodologic advantage of this series of cases is unique: because the perpetrators have pled
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36 guilty or been convicted, the presence of elder abuse has been verified and the time of detection
37
38 is known. This dataset includes rich information about the abuse victims and perpetrators as well
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40 as details about the abuse history, when and how it was detected, and the surrounding
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42 circumstances. It was constructed using information from the legal case files, including: medical
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44 records, descriptions of Emergency Medical Services personnel and police interactions with the
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46 victim and perpetrator, victim statements, adult protective services files, court documents, and
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48 photographs of injuries.
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Medicare Data Linkage

We will link these legally adjudicated cases to Medicare claims data using identifying information including social security numbers and/or a combination of last name, date of birth and residential ZIP code. Fee-for-service Medicare data is the largest single repository of patient health care data for US older adults,⁶⁶ offering comprehensive information on utilization of a broad range of health care services for continuously enrolled individuals. Medicare claims data has been used successfully to analyze health care utilization and costs and to inform interventions and policies for a variety of chronic diseases.⁶⁷⁻⁷⁰ Additionally, claims data have been used to examine the impact on utilization and cost of socio-medical issues^{71,72} including excessive alcohol use.^{47,57,73} Medicare claims data have also been employed to provide insight into the characteristics of frequent utilizers of specific health services, such as the ED^{62,74} and hospital.⁷⁵

We plan to examine Medicare claims data for each case from 3 years before to 3 years after detection of elder abuse and will compare to controls. We will use files including the Master Beneficiary Summary File (enrollee demographics, monthly enrollment information, chronic conditions, annual summary of costs and service utilization), Medicare Provider Analysis and Review (MEDPAR) file (events of inpatient hospital and skilled nursing facility stays), Outpatient Claims, Carrier File (claims of physician services), Home Health Claims, and the Part D (prescription drug) Event File.⁷⁶

Measures

We describe the key measures of utilization we plan to use in Table 1. We intend to focus primarily on utilization of high-intensity, high cost health care services including ED visits and hospitalizations by elder abuse victims and non-victim control subjects. We will examine overall

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3 utilization of these services and will also look at several characteristics of this utilization. We
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5 will examine the frequency of ED use and hospitalization among victims and compare utilization
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7 of these services of victims and non-victim controls. We will focus on injury-related utilization,
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9 using ICD codes and external cause of injury codes^{77,78} similar to previous work in child
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11 abuse.^{56,79} We will also examine frequent ED use, defined as 4 or more visits in a year, the cut-
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13 off accepted in the literature and used in previous Medicare research.^{62,74,80,81} We plan to
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15 measure the number of potentially avoidable low-urgency ED visits^{82,83} as well as ED visits and
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17 hospitalizations for ambulatory care-sensitive conditions (ACSCs). We will define low urgency
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19 visits similar to previous literature^{82,83} using Medicare Current Procedural Terminology (CPT)
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21 billing codes (99281, 99282) indicating low severity and no additional procedures billed. For this
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23 research, we will use the 11 ACSCs established for use in Medicare data.⁴⁶ We will also examine
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25 repeat ED visits and re-hospitalizations within short intervals. Consistent with previous research,
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27 we will examine visits to the ED within 3 days, 7 days, and 30 days of initial visit^{50,52} as well as
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29 repeat hospitalizations within 30 days and 90 days of initial hospitalization.⁵¹ Additionally, we
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31 will explore use of multiple EDs and hospitals.
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38 For outpatient care, we will examine the number of primary care visits and focus on
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40 injury-related visits for victims and controls. We will also examine changes in primary care
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42 providers. We plan to evaluate the continuity of care using the widely employed Continuity of
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44 Care Index (COCI).⁶³ Given that the COCI requires multiple outpatient visits to be meaningfully
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46 calculated, we will only examine this variable for subjects with three or more outpatient visits,
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48 consistent with previous literature.^{62,84,85} We will measure whether physical elder abuse victims
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50 and control subjects received preventative services, including influenza vaccination, glaucoma
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52 screening, pneumonia vaccination, and mammogram.⁵⁷ We plan to examine adherence to
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3 medication for chronic conditions. To do this, we will measure the proportion of days
4 covered^{86,87} and determine adherent vs. non-adherent using 0.80 as a cut-off, a common research
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6 strategy in administrative claims data.^{87,88}
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10 We will examine demographic data, including age, gender, and race/ethnicity. We will
11 also use claims data for key health-related co-variables to allow for further characterization of
12 physical elder abuse victims and comparison of sub-groups. These include medical co-
13 morbidities, psychiatric co-morbidities, dementia, and frailty. For medical co-morbidities, we
14 plan to use chronic condition indicators within the Medicare Master Beneficiary file, and we will
15 use psychiatric diagnoses within claims data. We will use an established approach^{35,89,90} to
16 identify dementia. To identify frailty, we will use a recently-developed algorithm designed for
17 use in Medicare claims data.^{91,92}
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31 *Non-Victim Control Subjects*

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33 We will select a group of non-victim control subjects matched to the cases on age, race,
34 gender, and residential ZIP code at the time of detection of each elder abuse case. This control
35 group will allow us to compare health care utilization of elder abuse victims with that of a
36 general older adult population. We will construct a second control group who, in addition to
37 being matched to the cases on age, race, gender, and ZIP code, visited the ED for an
38 unintentional injury within one week of the victim's abuse detection by law enforcement. This
39 second control group will allow us to explore potential differences between older adults
40 presenting to the ED for abuse-related injuries and those presenting with unintentional injuries, a
41 key focus of our previous research.^{93,94} Findings from such comparisons may assist health care
42 providers, particularly in the ED, to differentiate between physical elder abuse and unintentional
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3 injuries, informing future development of clinical algorithms to assist in this identification.
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5 Because we may have more controls than needed meeting the selection criteria within the first
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7 control cohort outlined above, we will further conduct propensity score matching to select
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9 controls that more closely match with the cases.
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12 We recognize that older adults selected as control subjects may actually be victims of
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14 physical elder abuse. To minimize the likelihood of this, we will ensure that all selected controls
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16 have never received any elder maltreatment-related diagnosis within Medicare claims data.
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21 *Focus on Physical Abuse*

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24 Though physical elder abuse may occur less frequently than other types of mistreatment,
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26 we think that focusing on these cases is a strength of our approach. Researchers have recognized
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28 that elder mistreatment is not a monolithic phenomenon and that etiologies, victim and
29
30 perpetrator characteristics, risk factors, clinical features, and sequelae likely differ in important
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32 ways between mistreatment types.⁹⁵ An important reason that previous research has yielded
33
34 inconsistent findings and little clinically useful information is likely that heterogeneous cases
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36 were analyzed together. We have chosen to focus on physical abuse because this violent
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38 mistreatment may be particularly dangerous for an older adult. Our research focuses on health
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40 care utilization for abuse victims and the potential for improving early identification in health
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42 care settings such as the emergency department. Given that physical abuse often causes acute
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44 injury which may trigger health care visits more commonly than other types of elder
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46 mistreatment, health care providers may have a particular opportunity to identify it. Linking
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48 known elder abuse cases to Medicare claims data to describe rates and patterns of health care
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3 utilization may also be used to examine victims of other types of elder mistreatment, though, and
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5 we plan to explore this in the future.
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8 9 10 *Analysis*

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12 We will conduct descriptive longitudinal analysis of health care utilization up to 3 years
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14 before and 3 years after the detection of elder abuse (and among control cohorts). For each elder
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16 abuse case, we will determine the calendar month in which the case was detected (the “index
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18 month”). We will then group months before and after the index month into 3-month
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20 intervals/quarters. Our unit of analysis will be patient-quarter. We will plot measured outcomes
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22 over time (centered around the index month) and visualize level of utilization in time blocks in
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24 relationship to the index month.
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27
28 We will compare utilization between physical elder abuse cases and non-victim control
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30 subjects using the key measures described above, focusing on identifying important differences.
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32 Comparisons will also specifically focus on rates of radiographic utilization of maxillofacial CT
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34 scan and forearm x-rays as well as diagnoses including acute or chronic facial or chronic ulnar
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36 fracture, and chronic rib fracture as they have been found to be potential predictors of physical
37
38 elder abuse.⁹⁶ We will compare total costs between cases and controls and then examine in detail
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40 contributing costs associated with each type of utilization.
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44 We will also conduct statistical modelling of longitudinal healthcare utilization outcomes
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46 to estimate adjusted differences between physical elder abuse victims and non-victims at various
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48 time points before and after the index month. For example, for the dichotomous outcome of any
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50 ED or inpatient admission in a quarter, we will estimate a mixed logistic regression where major
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52 covariates include victim status, time (relative to index month), and interaction of victim status
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3 and time, controlling for individual demographics and comorbidities. Random effects will be
4 specified at the patient level (to account for repeated measures of the same individual) and zip
5 code (to account for clustering of patients within the same zip code) levels.
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10 We have conducted power calculations with these cases and controls, incorporating
11 assumptions about Medicare linking rate (50% of cases), number of quarters of data contributed
12 by each individual (6 quarters), percentage of subjects with ≥ 1 ED visit in a quarter (12% of
13 elder abuse victims and 6% of controls), and intra cluster correlation (0.2, to account for
14 clustering of quarters within the same individual). Using these assumptions, we have a power of
15 0.82, which is adequate to identify important differences in utilization between cases and
16 controls.
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28 *Using Machine Learning*

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30 The comparative statistical analysis described above will illuminate the trajectories of
31 health care use one type at a time. It lacks the ability to integrate multi-dimensional data that,
32 combined, forms unique patterns of care. Recent innovations in machine learning make it
33 possible to use vast amounts of data, such as service utilization, diagnoses received, and
34 procedures performed, to identify sequences and mix of clinical events likely to lead to particular
35 outcomes or suggestive of an underlying disease process for different cohorts of patients.⁹⁷⁻¹⁰²
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37 For example, sequential pattern mining has been used in child abuse to examine patterns of
38 services provided to victims.^{103,104} To supplement the proposed statistical analysis, we propose to
39 search for features within claims data that may be suggestive that an older adult is a victim of
40 abuse. We will use Sequential PAttern Discovery using Equivalence classes (SPADE),¹⁰⁵ a well-
41 established algorithm which identifies patterns that are observed more than a user-defined
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3 frequency threshold in a cohorts' sequences of event. In addition, we will use Markov
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5 modeling¹⁰⁶ to identify the probabilities of observed patterns and associated underlying status of
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7 abuse to better distinguish patterns that are unique to elderly abused patients. We may find, for
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9 example, that a significant percentage of abuse victims have two ED visits and a hospitalization
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11 within a 3-month period and receive forearm x-rays and are diagnosed with a fracture, but this
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13 pattern is never seen in controls.
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16 17 18 19 *Patient and public involvement*

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21 We plan to involve older adults including victims of elder mistreatment in the reporting
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23 and dissemination for this this research.
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26 27 28 29 *Timeline*

30 This research was initiated in 2018 and we plan to report results by 2023.
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33 34 35 *Discussion*

36 This ongoing work will address a significant gap in current knowledge about elder abuse
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38 by improving understanding of how physical abuse victims use health care services differently
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40 than non-victims as well as associated costs. We anticipate insights from our findings will
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42 generate hypotheses that may be tested in future studies in different populations and among
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44 victims of different types of elder mistreatment. We also expect that this work will lead to
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46 additional uses of claims data to explore the health consequences of elder abuse and to identify
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48 utilization patterns with “red flags” suggestive of exposure. Ultimately, we anticipate that
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50 knowledge gleaned will support the future development of a health informatics tool to identify
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52 potential victims.
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3 An important limitation of our approach is the use of legally adjudicated cases. Though
4 using this source solves the important methodologic challenge of ensuring that case subjects are
5 actually victims of abuse, legally adjudicated cases represent a small percentage of all cases, and
6 abuse victims included may differ in important ways from other victims. They may have
7 experienced more acute or severe abuse allowing identification, and subtle cases of abuse that
8 are more challenging to detect may not have been included. Additionally, other circumstances
9 surrounding the case including the availability of evidence, the willingness of the victim to
10 participate, jurisdiction's practice pattern may have impacted the decision to prosecute the
11 perpetrator, significantly reducing potential generalizability. An important challenge in previous
12 studies has been accurately classifying subjects as victims of mistreatment. This has likely
13 contributed to inconsistent research findings. Our new potential approach will generate
14 trustworthy results that may identify patterns and generate hypotheses that may be tested. We
15 anticipate that rigorous studies such as ours will lay the necessary groundwork for future studies
16 focused on identifying and examining more subtle cases.
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35 Also, our research strategy relies on linking to Medicare Fee-for-Service records. If
36 subjects were covered by Medicare Advantage or otherwise not covered by Medicare Fee-For-
37 Service for any period, information about their health care utilization would not be available
38 during that period. We have incorporated this potential into our power calculation assumptions,
39 however, and believe we will be able to identify important differences in utilization.
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47 Another important limitation is that selected control subjects may actually be unidentified
48 cases, reducing the accuracy of our conclusions. Using elder mistreatment diagnoses within
49 Medicare data is not an ideal method for ensuring controls are not cases, given that these
50 diagnoses are infrequently and unreliably included. We hope to overcome this limitation by
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3 selecting multiple control cohorts, each with large numbers of controls. Using this approach, and
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5 performing sensitivity analyses on our findings, will allow us to identify patterns and draw
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7 meaningful conclusions even if a small number of controls are actually abuse victims.
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10 Although we believe that machine learning techniques have enormous potential to find
11
12 subtle patterns, it is possible that we will not identify any that are clinically identifiable or
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14 meaningful. Despite these potential limitations, we believe this research offers a unique
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16 opportunity to use a large series of well-characterized cases of physical elder abuse to help us
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18 understand the health-related markers that can be used to more validly predict elder abuse, and
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20 thereby prevent it.
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24 Improved understanding of patterns and associated costs of health care utilization among
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26 elder abuse victims, which likely differs substantially from that of other older adults, is
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28 potentially very valuable. It may improve the ability of health care providers to identify,
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30 intervene, and prevent victimization. Further, it may inform policy changes to reduce costs and
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32 help this vulnerable population. The research described here represents an important step in
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34 exploring the potential of examining health care utilization to provide insight into elder abuse
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36 and how to address it.
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Ethics and Dissemination

This project has been reviewed and approved by the Weill Cornell Medicine Institutional Review Board, protocol #1807019417, with initial approval on August 1, 2018. We aim to disseminate our results in peer-reviewed journals, at national and international conferences and among interested patient groups and the public.

For peer review only

References

1. Acierno R, Hernandez MA, Amstadter AB, et al. Prevalence and correlates of emotional, physical, sexual, and financial abuse and potential neglect in the United States: the National Elder Mistreatment Study. *Am J Public Health* 2010;100:292-7.
2. Lachs MS, Pillemer K. Elder abuse. *Lancet* 2004;364:1263-72.
3. Under the Radar: New York State Elder Abuse Prevalence Study: Self-Reported Prevalence and Documented Case Surveys 2012. (Accessed February 10, 2020, at <https://ocfs.ny.gov/main/reports/Under%20the%20Radar%2005%2012%2011%20final%20report.pdf>)
4. National Research Council. Elder mistreatment: Abuse, neglect and exploitation in an aging America. Washington, DC: The National Academies Press; 2003.
5. National Center for Elder Abuse. The Elder Justice Roadmap: A Stakeholder Initiative to Respond to an Emerging Health, Justice, Financial, and Social Crisis. (Accessed February 10, 2020, at <https://www.justice.gov/file/852856/download>)
6. Lachs MS, Pillemer KA. Elder abuse. *N Engl J Med* 2015;373:1947-56.
7. Schofield MJ, Powers JR, Loxton D. Mortality and disability outcomes of self-reported elder abuse: a 12-year prospective investigation. *J Am Geriatr Soc* 2013;61:679-85.
8. Dyer CB, Pavlik VN, Murphy KP, Hyman DJ. The high prevalence of depression and dementia in elder abuse or neglect. *J Am Geriatr Soc* 2000;48:205-8.
9. Lachs MS, Williams CS, O'Brien S, Pillemer KA, Charlson ME. The mortality of elder mistreatment. *JAMA* 1998;280:428-32.
10. Dong XQ, Simon MA, Beck TT, et al. Elder abuse and mortality: the role of psychological and social wellbeing. *Gerontology* 2011;57:549-58.

- 1
2
3 11. Baker MW, LaCroix AZ, Wu C, Cochrane BB, Wallace R, Woods NF. Mortality risk
4 associated with physical and verbal abuse in women aged 50 to 79. *J Am Geriatr Soc*
5
6 2009;57:1799-809.
7
- 8
9
10 12. Pillemer K, Finkelhor D. The prevalence of elder abuse: a random sample survey.
11
12 *Gerontologist* 1988;28:51-7.
13
- 14 13. Murphy K, Waa S, Jaffer H, Sauter A, Chan A. A literature review of findings in physical
15
16 elder abuse. *Can Assoc Radiol J* 2013;64:10-4.
17
- 18 14. Lachs MS, Williams CS, O'Brien S, et al. ED use by older victims of family violence. *Ann*
19
20 *Emerg Med* 1997;30:448-54.
21
- 22 15. Bond MC, Butler KH. Elder abuse and neglect: definitions, epidemiology, and approaches
23
24 to emergency department screening. *Clin Geriatr Med* 2013;29:257-73.
25
- 26 16. Geroff AJ, Olshaker JS. Elder abuse. *Emerg Med Clin North Am* 2006;24:491-505.
27
- 28 17. Dong X, Simon MA. Association between elder abuse and use of ED: findings from the
29
30 Chicago Health and Aging Project. *Am J Emerg Med* 2013;31:693-8.
31
- 32 18. Friedman LS, Avila S, Tanouye K, Joseph K. A case-control study of severe physical abuse
33
34 of older adults. *J Am Geriatr Soc* 2011;59:417-22.
35
- 36 19. Heyborne RD. Elder abuse: keeping the unthinkable in the differential. *Acad Emerg Med*
37
38 2007;14:566-7.
39
- 40 20. Chan KL, Choi WM, Fong DY, Chow CB, Leung M, Ip P. Characteristics of family
41
42 violence victims presenting to emergency departments in Hong Kong. *J Emerg Med*
43
44 2013;44:249-58.
45
- 46 21. Dong X, Simon MA. Elder abuse as a risk factor for hospitalization in older persons. *JAMA*
47
48 *Intern Med* 2013;173:911-7.
49
50
51
52
53
54
55
56
57
58
59
60

- 1
 - 2
 - 3
 - 4
 - 5
 - 6
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 - 46
 - 47
 - 48
 - 49
 - 50
 - 51
 - 52
 - 53
 - 54
 - 55
 - 56
 - 57
 - 58
 - 59
 - 60
22. Lachs MS, Williams CS, O'Brien S, Pillemer KA. Adult protective service use and nursing home placement. *Gerontologist* 2002;42:734-9.
23. Dong X, Simon MA. Association between reported elder abuse and rates of admission to skilled nursing facilities: findings from a longitudinal population-based cohort study. *Gerontology* 2013;59:464-72.
24. Mouton CP, Rodabough RJ, Rovi SL, et al. Prevalence and 3-year incidence of abuse among postmenopausal women. *Am J Public Health* 2004;94:605-12.
25. Jackson AM, Deye KP, Halley T, et al. Curiosity and critical thinking: identifying child abuse before it is too late. *Clin Pediatr* 2015;54:54-61.
26. Jenny C, Hymel KP, Ritzen A, Reinert SE, Hay TC. Analysis of missed cases of abusive head trauma. *JAMA* 1999;281:621-6.
27. King WK, Kiesel EL, Simon HK. Child abuse fatalities: are we missing opportunities for intervention? *Pediatr Emerg Care* 2006;22:211-4.
28. Letson MM, Cooper JN, Deans KJ, et al. Prior opportunities to identify abuse in children with abusive head trauma. *Child Abuse Negl* 2016;60:36-45.
29. Ravichandiran N, Schuh S, Bejuk M, et al. Delayed identification of pediatric abuse-related fractures. *Pediatrics* 2010;125:60-6.
30. Thorpe EL, Zuckerbraun NS, Wolford JE, Berger RP. Missed opportunities to diagnose child physical abuse. *Pediatr Emerg Care* 2014;30:771-6.
31. Kothari CL, Rhodes KV. Missed opportunities: emergency department visits by police-identified victims of intimate partner violence. *Ann Emerg Med* 2006;47:190-9.
32. Willson P, Cesario S, Fredland N, et al. Primary healthcare provider's lost opportunity to help abused women. *J Am Acad Nurse Pract* 2001;13:565-70.

- 1
- 2
- 3 33. Lindberg DM, Beaty B, Juarez-Colunga E, Wood JN, Runyan DK. Testing for abuse in
- 4 children with sentinel injuries. *Pediatrics* 2015;136:831-8.
- 5
- 6
- 7
- 8 34. Sheets LK, Leach ME, Koszewski IJ, Lessmeier AM, Nugent M, Simpson P. Sentinel
- 9 injuries in infants evaluated for child physical abuse. *Pediatrics* 2013;131:701-7.
- 10
- 11
- 12 35. Brown DS, Fang X, Florence CS. Medical costs attributable to child maltreatment a
- 13 systematic review of short- and long-term effects. *Am J Prev Med* 2011;41:627-35.
- 14
- 15
- 16
- 17 36. Rovi S, Chen PH, Johnson MS. The economic burden of hospitalizations associated with
- 18 child abuse and neglect. *Am J Public Health* 2004;94:586-90.
- 19
- 20
- 21 37. Florence C, Brown DS, Fang X, Thompson HF. Health care costs associated with child
- 22 maltreatment: impact on medicaid. *Pediatrics* 2013;132:312-8.
- 23
- 24
- 25
- 26 38. Jones AS, Dienemann J, Schollenberger J, et al. Long-term costs of intimate partner
- 27 violence in a sample of female HMO enrollees. *Womens Health Issues* 2006;16:252-61.
- 28
- 29
- 30 39. Peterson C, Xu L, Florence C, et al. The medical cost of abusive head trauma in the United
- 31 States. *Pediatrics* 2014;134:91-9.
- 32
- 33
- 34
- 35 40. Miller TR, Steinbeigle R, Lawrence BA, et al. Lifetime cost of abusive head trauma at ages
- 36 0-4, USA. *Prev Sci* 2017.
- 37
- 38
- 39
- 40 41. Fang X, Brown DS, Florence CS, Mercy JA. The economic burden of child maltreatment in
- 41 the United States and implications for prevention. *Child Abuse Negl* 2012;36:156-65.
- 42
- 43
- 44 42. Max W, Rice DP, Finkelstein E, Bardwell RA, Leadbetter S. The economic toll of intimate
- 45 partner violence against women in the United States. *Violence Vict* 2004;19:259-72.
- 46
- 47
- 48
- 49 43. Thielen FW, Ten Have M, de Graaf R, et al. Long-term economic consequences of child
- 50 maltreatment: a population-based study. *Eur Child Adolesc Psychiatry* 2016;25:1297-305.
- 51
- 52
- 53
- 54
- 55
- 56
- 57
- 58
- 59
- 60

- 1
2
3 44. Yang J, Miller TR, Zhang N, LeHew B, Peek-Asa C. Incidence and cost of sexual violence
4
5 in Iowa. *Am J Prev Med* 2014;47:198-202.
6
- 7
8 45. Teresi JA, Burnes D, Skowron EA, et al. State of the science on prevention of elder abuse
9
10 and lessons learned from child abuse and domestic violence prevention: Toward a
11
12 conceptual framework for research. *J Elder Abuse Negl* 2016;28:263-300.
13
- 14
15 46. McCall N. Centers for Medicare and Medicaid Services. Investigation of Increasing Rates of
16
17 Hospitalization for Ambulatory Care Sensitive Conditions Among Medicare Fee-for-Service
18
19 Beneficiaries. (Accessed on February 10, 2020, at: [https://www.cms.gov/Research-](https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/Reports/Downloads/McCall_2004_3.pdf)
20
21 [Statistics-Data-and-Systems/Statistics-Trends-and-](https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/Reports/Downloads/McCall_2004_3.pdf)
22
23 [Reports/Reports/Downloads/McCall_2004_3.pdf](https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/Reports/Downloads/McCall_2004_3.pdf))
24
25
- 26
27 47. Merrick ES, Hodgkin D, Garnick DW, et al. Older adults' inpatient and emergency
28
29 department utilization for ambulatory-care-sensitive conditions: relationship with alcohol
30
31 consumption. *J Aging Health* 2011;23:86-111.
32
- 33
34 48. Brownell J, Wang J, Smith A, Stephens C, Hsia RY. Trends in emergency department visits
35
36 for ambulatory care sensitive conditions by elderly nursing home residents, 2001 to 2010.
37
38 *JAMA Intern Med* 2014;174:156-8.
39
- 40
41 49. Carter MW, Datti B, Winters JM. ED visits by older adults for ambulatory care-sensitive
42
43 and supply-sensitive conditions. *Am J Emerg Med* 2006;24:428-34.
44
- 45
46 50. Duseja R, Bardach NS, Lin GA, et al. Revisit rates and associated costs after an emergency
47
48 department encounter: a multistate analysis. *Ann Intern Med* 2015;162:750-6.
49
- 50
51 51. Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the Medicare
52
53 fee-for-service program. *N Engl J Med* 2009;360:1418-28.
54
55
56
57
58
59
60

- 1
- 2
- 3 52. Liu SW, Obermeyer Z, Chang Y, Shankar KN. Frequency of ED revisits and death among
- 4 older adults after a fall. *Am J Emerg Med* 2015;33:1012-8.
- 5
- 6
- 7
- 8 53. Vashi AA, Fox JP, Carr BG, et al. Use of hospital-based acute care among patients recently
- 9 discharged from the hospital. *JAMA* 2013;309:364-71.
- 10
- 11
- 12 54. Ahmad M, Lachs MS. Elder abuse and neglect: what physicians can and should do. *Clev*
- 13 *Clin J Med* 2002;69:801-8.
- 14
- 15
- 16
- 17 55. Rosen T, Stern ME, Elman A, Mulcare MR. Identifying and initiating intervention for elder
- 18 abuse and neglect in the Emergency Department. *Clin Geriatr Med* 2018;34:435-51.
- 19
- 20
- 21 56. Friedlaender EY, Rubin DM, Alpern ER, Mandell DS, Christian CW, Alessandrini EA.
- 22 Patterns of health care use that may identify young children who are at risk for
- 23 maltreatment. *Pediatrics* 2005;116:1303-8.
- 24
- 25
- 26
- 27
- 28 57. Merrick EL, Hodgkin D, Garnick DW, et al. Unhealthy drinking patterns and receipt of
- 29 preventive medical services by older adults. *J Gen Intern Med* 2008;23:1741-8.
- 30
- 31
- 32
- 33 58. Asch SM, Sloss EM, Hogan C, Brook RH, Kravitz RL. Measuring underuse of necessary
- 34 care among elderly Medicare beneficiaries using inpatient and outpatient claims. *JAMA*
- 35 2000;284:2325-33.
- 36
- 37
- 38
- 39
- 40 59. Klabunde CN, Meissner HI, Wooten KG, Breen N, Singleton JA. Comparing colorectal
- 41 cancer screening and immunization status in older americans. *Am J Prev Med* 2007;33:1-8.
- 42
- 43
- 44 60. Ozminkowski RJ, Goetzel RZ, Shechter D, Stapleton DC, Baser O, Lapin P. Predictors of
- 45 preventive service use among Medicare beneficiaries. *Health Care Financ Rev* 2006;27:5-
- 46 23.
- 47
- 48
- 49
- 50
- 51
- 52
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- 54
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42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61. Scott TL, Gazmararian JA, Williams MV, Baker DW. Health literacy and preventive health care use among Medicare enrollees in a managed care organization. *Med Care* 2002;40:395-404.
 62. Colligan EM, Pines JM, Colantuoni E, Wolff JL. Factors Associated With Frequent Emergency Department Use in the Medicare Population. *Medical Care Res Rev* 2017;73:311-327.
 63. Bice TW, Boxerman SB. A quantitative measure of continuity of care. *Med Care* 1977;15:347-9.
 64. Jha AK, Aubert RE, Yao J, Teagarden JR, Epstein RS. Greater adherence to diabetes drugs is linked to less hospital use and could save nearly \$5 billion annually. *Health Aff (Millwood)* 2012;31:1836-46.
 65. Roebuck MC, Liberman JN, Gemmill-Toyama M, Brennan TA. Medication adherence leads to lower health care use and costs despite increased drug spending. *Health Aff (Millwood)* 2011;30:91-9.
 66. Mues KE, Liede A, Liu J, et al. Use of the Medicare database in epidemiologic and health services research: a valuable source of real-world evidence on the older and disabled populations in the US. *Clin Epidemiol* 2017;9:267-77.
 67. Chen J, Hsieh AF, Dharmarajan K, Masoudi FA, Krumholz HM. National trends in heart failure hospitalization after acute myocardial infarction for Medicare beneficiaries: 1998-2010. *Circulation* 2013;128:2577-84.
 68. Fitch K, Pelizzari PM, Pyenson B. Inpatient Utilization and Costs for Medicare Fee-for-Service Beneficiaries with Heart Failure. *Am Health Drug Benefits* 2016;9:96-104.

- 1
2
3 69. Genao L, Durheim MT, Mi X, Todd JL, Whitson HE, Curtis LH. Early and Long-term
4 Outcomes of Older Adults after Acute Care Encounters for Chronic Obstructive Pulmonary
5 Disease Exacerbation. *Ann Am Thorac Soc* 2015;12:1805-12.
6
7
8
9
10 70. Wetmore JB, Peng Y, Jackson S, Matlon TJ, Collins AJ, Gilbertson DT. Patient
11 characteristics, disease burden, and medication use in stage 4 - 5 chronic kidney disease
12 patients. *Clin Nephrol* 2016;85:101-11.
13
14
15
16
17 71. Baicker K, Chandra A, Skinner JS, Wennberg JE. Who you are and where you live: how
18 race and geography affect the treatment of medicare beneficiaries. *Health Aff*
19 (Millwood):VAR33-44.
20
21
22
23
24 72. Joynt KE, Orav EJ, Jha AK. Thirty-day readmission rates for Medicare beneficiaries by race
25 and site of care. *JAMA* 2011;305:675-81.
26
27
28
29 73. Merrick EL, Horgan CM, Hodgkin D, et al. Unhealthy drinking patterns in older adults:
30 prevalence and associated characteristics. *J Am Geriatr Soc* 2008;56:214-23.
31
32
33 74. Colligan EM, Pines JM, Colantuoni E, Howell B, Wolff JL. Risk Factors for Persistent
34 Frequent Emergency Department Use in Medicare Beneficiaries. *Ann Emerg Med*
35 2016;67:721-9.
36
37
38
39
40 75. Phongtankuel V, Johnson P, Reid MC, et al. Risk factors for hospitalization of home
41 hospice enrollees. *Am J Hosp Palliat Care* 2016:1049909116659439.
42
43
44
45 76. ResDAC Research Data Assistance Center. Data Availability. (Accessed on February 10,
46 2020 at <https://www.resdac.org/cms-data/file-availability>.)
47
48
49 77. Annest JL, Fingerhut LA, Gallagher SS, et al. Strategies to improve external cause-of-injury
50 coding in state-based hospital discharge and emergency department data systems:
51
52
53
54
55
56
57
58
59
60

- 1
2
3 recommendations of the CDC Workgroup for Improvement of External Cause-of-Injury
4 Coding. *MMWR Recomm Rep* 2008;57:1-15.
5
6
7
8 78. Coben JH, Steiner CA, Barrett M, Merrill CT, Adamson D. Completeness of cause of injury
9 coding in healthcare administrative databases in the United States, 2001. *Inj Prev*
10 2006;12:199-201.
11
12
13
14 79. Spivey MI, Schnitzer PG, Kruse RL, Slusher P, Jaffe DM. Association of injury visits in
15 children and child maltreatment reports. *J Emerg Med* 2009;36:207-14.
16
17
18
19 80. LaCalle E, Rabin E. Frequent users of emergency departments: the myths, the data, and the
20 policy implications. *Ann Emerg Med* 2010;56:42-8.
21
22
23
24 81. Locker TE, Baston S, Mason SM, Nicholl J. Defining frequent use of an urban emergency
25 department. *Emerg Med J* 2007;24:398-401.
26
27
28
29 82. Davis JW, Fujimoto RY, Chan H, Juarez DT. Identifying characteristics of patients with low
30 urgency emergency department visits in a managed care setting. *Manag Care* 2010;19:38-
31 44.
32
33
34
35 83. Uscher-Pines L, Pines J, Kellermann A, Gillen E, Mehrotra A. Emergency department visits
36 for nonurgent conditions: systematic literature review. *Am J Manag Care* 2013;19:47-59.
37
38
39
40 84. Bayliss EA, Ellis JL, Shoup JA, Zeng C, McQuillan DB, Steiner JF. Effect of continuity of
41 care on hospital utilization for seniors with multiple medical conditions in an integrated
42 health care system. *Ann Fam Med* 2015;13:123-9.
43
44
45
46 85. Liss DT, Chubak J, Anderson ML, Saunders KW, Tuzzio L, Reid RJ. Patient-reported care
47 coordination: associations with primary care continuity and specialty care use. *Ann Fam*
48 *Med* 2011;9:323-9.
49
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3 86. Hess LM, Raebel MA, Conner DA, Malone DC. Measurement of adherence in pharmacy
4 administrative databases: a proposal for standard definitions and preferred measures. *Ann*
5
6 *Pharmacother* 2006;40:1280-88.
7
8
- 9
10 87. Karve S, Cleves MA, Helm M, Hudson TJ, West DS, Martin BC. Good and poor adherence:
11 optimal cut-point for adherence measures using administrative claims data. *Curr Med Res*
12
13 *Opin* 2009;25:2303-10.
14
15
- 16 88. Colantonio LD, Huang L, Monda KL, et al. Adherence to High-Intensity Statins Following
17 a Myocardial Infarction Hospitalization Among Medicare Beneficiaries. *JAMA Cardiol*
18
19 2017;2:890-5.
20
21
- 22 89. Ostbye T, Taylor DH, Jr., Clipp EC, Scoyoc LV, Plassman BL. Identification of dementia:
23 agreement among national survey data, medicare claims, and death certificates. *Health Serv*
24
25 *Res* 2008;43:313-26.
26
27
- 28 90. Taylor DH, Jr., Fillenbaum GG, Ezell ME. The accuracy of medicare claims data in
29 identifying Alzheimer's disease. *J Clin Epidemiol* 2002;55:929-37.
30
31
- 32 91. Faurot KR, Jonsson Funk M, Pate V, et al. Using claims data to predict dependency in
33 activities of daily living as a proxy for frailty. *Pharmacoepidemiol Drug Saf* 2015;24:59-66.
34
35
- 36 92. Zhang HT, McGrath LJ, Wyss R, Ellis AR, Sturmer T. Controlling confounding by frailty
37 when estimating influenza vaccine effectiveness using predictors of dependency in activities
38
39 of daily living. *Pharmacoepidemiol Drug Saf* 2017.
40
41
- 42 93. Rosen T, Bloemen EM, LoFaso VM, Clark S, Flomenbaum NE, Lachs MS. Emergency
43
44 Department presentations for injuries in older adults independently known to be victims of
45
46 elder abuse. *J Emerg Med* 2016;50:518-26.
47
48
49
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3 94. Rosen T, LoFaso V, Bloemen EM, et al. Injury patterns in physical elder abuse: preliminary
4 findings from a pilot sample of highly adjudicated cases. Society of Academic Emergency
5 Medicine Annual Scientific Meeting. San Diego 2015.
6
7
8
9
10 95. Jackson, S. Understanding elder abuse: new directions for developing theories of elder
11 abuse occurring in domestic settings. 2013. (Accessed on February 10, 2020, at
12 <https://www.ncjrs.gov/pdffiles1/nij/241731.pdf>)
13
14
15
16
17 96. Wong NZ, Rosen T, Sanchez AM, et al. Imaging findings in elder abuse: a role for
18 radiologists in detection. *Can Assoc Radiol J* 2017;68:16-20.
19
20
21 97. Zhang Y, Padman R. Paving the COWPath: Learning and Visualizing Clinical Pathways
22 from Electronic Health Record Data. Carnegie Mellon University; 2015.
23
24
25
26 98. Movahedi F, Carey L, Zhang Y, Padman R, Antaki J. Care pathway after Left Ventricular
27 Assist Devices (LVAD) implementation. International Society for Heart and Lung
28 Transplantation. San Diego, CA 2017.
29
30
31
32
33 99. Ghosh S, Li J, Cao L, Ramamohanarao K. Septic shock prediction for ICU patients via
34 coupled HMM walking on sequential contrast patterns. *J Biomed Inform* 2017;66:19-31.
35
36
37
38 100. Kawamoto R, Nazir A, Kameyama A, et al. Hidden Markov model for analyzing time-series
39 health checkup data. *Stud Health Technol Inform* 2013;192:491-5.
40
41
42
43 101. Watkins RE, Eagleson S, Veenendaal B, Wright G, Plant AJ. Disease surveillance using a
44 hidden Markov model. *BMC Med Inform Decis Mak* 2009;9:39.
45
46
47 102. Zhang Y, Padman R. Innovations in chronic care delivery using data-driven clinical
48 pathways. *Am J Manag Care* 2015;21:e661-8.
49
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3 103. Duncan DF, Kum HC, Weigensberg EC, Flair KA, Stewart CJ. Informing child welfare
4
5 policy and practice: Using knowledge discovery and data mining technology via a dynamic
6
7 web site. *Child Maltreat* 2008;13:383-91.
8
9
- 10 104. Hye-Chung (Monica) Kum JP, Wei Wang, Dean Duncan. ApproxMAP: Approximate
11
12 Mining of Consensus Sequential Patterns. (Accessed on February 10, 2020 at
13
14 <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.12.2633&rep=rep1&type=pdf>)
15
16
- 17 105. Zaki MJ. SPADE: An Efficient Algorithm for Mining Frequent Sequences. *Machine*
18
19 Learning 2001;42:31-60.
20
- 21 106. Rabiner L. A tutorial on hidden Markov models and selected applications in speech
22
23 recognition. *IEEE* 1989. (Accessed on February 10, 2020 at
24
25 [http://www.ece.ucsb.edu/Faculty/Rabiner/ece259/Reprints/tutorial%20on%20hmm%20and](http://www.ece.ucsb.edu/Faculty/Rabiner/ece259/Reprints/tutorial%20on%20hmm%20and%20applications.pdf)
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27 [%20applications.pdf](http://www.ece.ucsb.edu/Faculty/Rabiner/ece259/Reprints/tutorial%20on%20hmm%20and%20applications.pdf))
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Figure 1: Conceptual Framework for Health Care Utilization by Elder Abuse Victims

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Table 1: Selected Key Measures of Health Care Utilization

Site / Type	Utilization Measure
Emergency Department	<ul style="list-style-type: none"> • Injury-related visits • Total visits, including identification of high-frequency users • Low urgency visits, visits for ambulatory care sensitive conditions • Repeat visits to the ED within 3 days, 7 days, 30 days of initial visit • Visits to multiple EDs
Hospital	<ul style="list-style-type: none"> • Injury-related hospitalizations • Total hospitalizations • Visits for ambulatory care sensitive conditions • Repeat hospitalizations within 30 days, 90 days of initial hospitalization • Visits to multiple hospitals
Outpatient	<ul style="list-style-type: none"> • Injury-related visits to primary care provider • Total visits to primary care provider • Receipt of preventative services • Periods with no primary care provider selected • Changes to primary care provider • Continuity of care (via Continuity of Care Index) • Medication adherence (via Proportion of Days Covered)

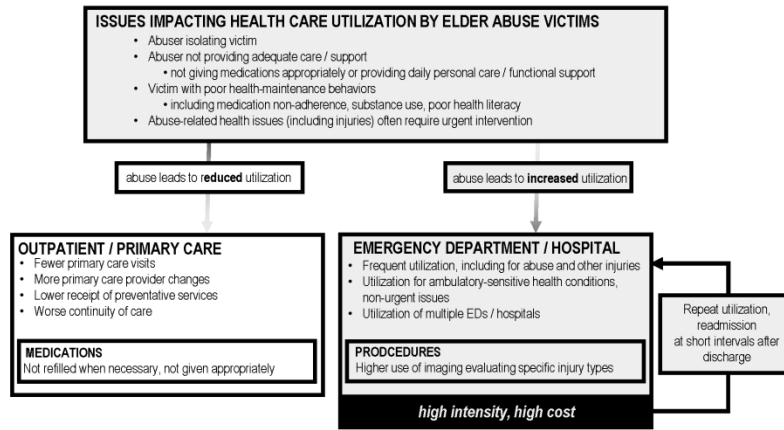


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