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Creating an Optimal Environment for Quality Healthcare for Individuals, Families, and Communities

# Incremental Cost of Medicare Beneficiary Hospital Readmissions: Valuation via a Robust Machine Learning Approach


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# Highlights

- Granular valuation of the incremental cost of Medicare beneficiary hospital readmissions (top 26 condition categories targeted in this study)
- Apply a previously unused approach (causal inference & machine learning) in the valuation
- Compare machine learning (ensemble models) in valuation to the traditional unadjusted or parametric model estimation methods
- We observe that the incremental cost of a **schizophrenia** readmission was undervalued by over $3000 in the parametric model

# Introduction

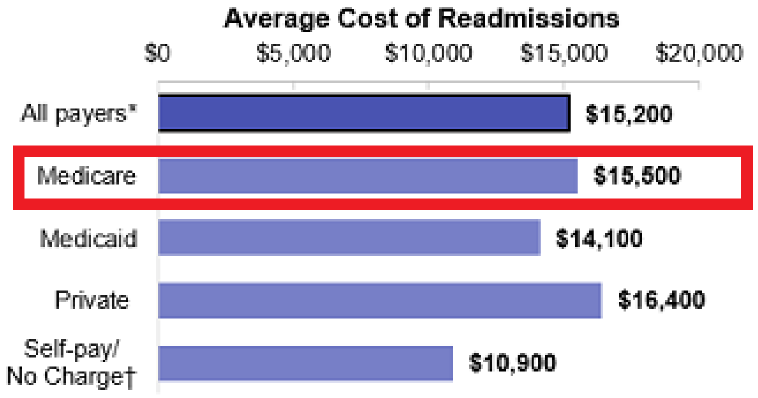
- Risk adjustment in health plan payment aims to redistribute funds according to the likely cost of enrollees
- Plans with costlier enrollees should receive larger payments than plans with less expensive enrollees (Iezzoni, 1997)
- Similarly, readmission risk varies in the Medicare population (Jencks, 2009; Bradford, 2017; Joynt, 2011)
- However, valuation of the cost of hospital readmissions has largely been estimated in an “all-cause” manner
- Where they are by condition, they are unadjusted (Weiss & Jiang, 2021) or estimated from adjusted parametric models (Carey & Stefos, 2015)

# Introduction (continued)

- Hospital readmissions remains a major target in CMS's cost reduction agenda
- In CMS's 12th SOW, QIN-QIOs were required to report savings from 30-day readmissions and other measures
- All QIN-QIOs were presented with a single "all-cause" estimate as the cost of a hospital readmission
- This rate multiplied by number of *readmissions avoided (expected minus actual)* by the QIN-QIO yielded savings

# Unadjusted estimates from Weiss & Jiang, 2021

**Figure 1 a. Average readmission cost by payer**




**b. Top 5 most expensive readmissions conditions**

Table 3. Top five principal diagnoses with the highest average cost of 30-day all-cause adult hospital readmissions, by expected payer, 2018

| Principal diagnosis at index admission | Number of index admissions | 30-day readmissions | | | Percent of total payer-specific readmission costs |
|---|---|---|---|---|---|
| | | Rank | Average cost, $ | Aggregate cost, $ millions | |
| **Medicare** | **13,533,200** | - | **15,500** | **35,500** | **100.0** |
| Chronic rheumatic heart disease | 16,100 | 1 | 25,800 | 87 | 0.2 |
| Complication of transplanted organs or tissue, initial encounter | 27,100 | 2 | 24,200 | 180 | 0.5 |
| Nonrheumatic and unspecified valve disorders | 96,000 | 3 | 22,500 | 359 | 1.0 |
| Diseases of white blood cells | 13,100 | 4 | 21,800 | 79 | 0.2 |
| Aortic; peripheral; and visceral artery aneurysms | 45,000 | 5 | 21,300 | 121 | 0.3 |

Source: Weiss & Jiang (2021).
Adult hospital readmissions by expected payer. Analysis of Nationwide Readmissions Database (NRD), 2018.

# A Condition-Specific ML Framework (*Rose, 2018*)

- An experiment where one randomly samples a unit from the population and measure baseline features, medical conditions, and total payment from index and readmission periods

- We are interested in estimating how much more, on average, Medicare patients with **26 common index diagnoses** cost when they are readmitted within 30 days of discharge (compared to similar not readmitted)

- Baseline controls include patient age, sex, race, state, length of stay, and up to 25 diagnoses (binary flags)

- The outcome variable is CMS's total payment to the provider during the index and readmission periods

# Targeted Maximum Likelihood Estimation (TMLE) 1

- Targeted Maximum Likelihood Estimation (TMLE) is a causal inference framework used to estimate a statistical quantity of interest
- It allows the **use of machine learning (ML)** models in the process
- ML places **minimal assumptions** on the distribution of the data
- An ML approach known as "superlearning" is commonly used in TMLE
- Superlearning **combines several models** to make predictions, and is theoretically as-good-as or better than any of the individual models
- In this study, our ensemble models were *generalized linear model*, *boosting*, *lasso*, and *neural network*

# Targeted Maximum Likelihood Estimation (TMLE) 2

- Let ***B*** denote baseline variables
- ***M*** is a vector of medical condition categories
- ***A*** denotes the current medical condition category under consideration
- $\boldsymbol{M^{-}}$ represents *the vector M* that excludes the variable *A*
- ***Y*** is the outcome, the total medical cost paid
- ***R*** is a binary readmission indicator (i.e., ***R = 1*** implies readmitted, 0 otherwise)
- We assume a nonparametric model and define the parameter of interest as:

$$\emptyset = \boldsymbol{E_{W,M^{-}}[E(Y \backslash A = 1, R = 1, W, M^{-}) - E(Y \backslash A = 1, R = 0, W, M^{-})]}$$

- This represents the effect of readmitted ***(R = 1)*** versus not readmitted ***(R = 0)*** *for condition category* ***A,*** adjusting for baseline variables and comorbidities

# Data

- Medicare FFS claims, 2021 - 2022
- All inpatient beneficiaries in Pennsylvania and West Virginia
- 933,255 observations (117,010 excluded)
- 18.7% readmission rate
- Median index length of stay of 4 days
- 9,971 unique *primary* diagnosis codes (recoded to 87 hierarchical condition categories (HCCs))

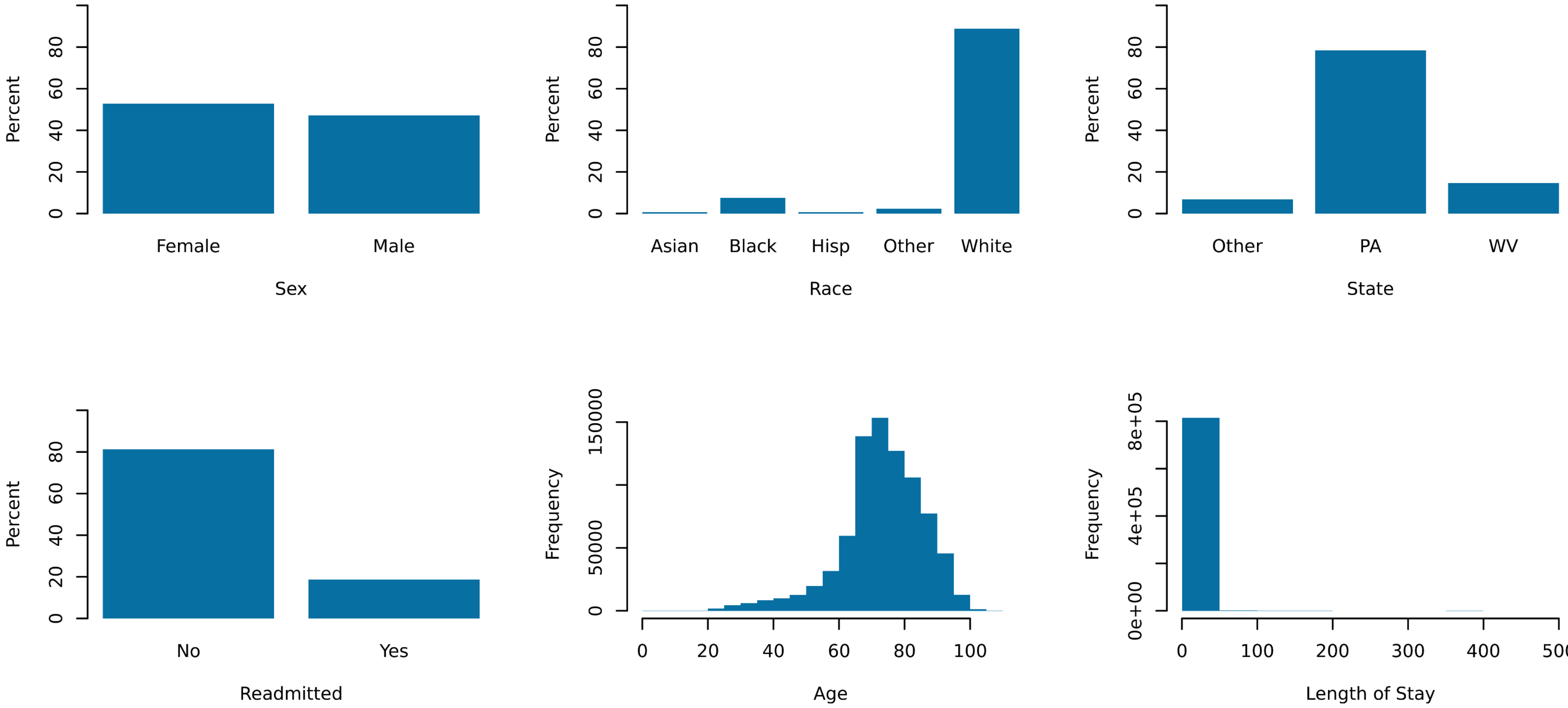
# Readmission

- A 30-day readmission occurs when the beneficiary's "index" inpatient discharge is followed by an inpatient admission having an admission date within 30 days of the index inpatient discharge date
- **DENOMINATOR**
  - Medicare Fee-for-Service (FFS) Part A beneficiaries with Part A coverage for any days of the reporting time period
- **NUMERATOR**

30-day readmissions among beneficiaries contributing to the denominator

- **Inclusions**
  - Readmissions within 30 days of index **inpatient discharge** that occurred during the period in **short-term hospitals, critical access hospitals, and inpatient psychiatric hospitals and units**
- **Exclusions**
  - Principal/first-listed diagnosis of COVID-19
  - Principal diagnosis of Sepsis or Transplant Complication **with COVID-19 in any secondary position**

# Figure 1. Characteristics of hospitalized beneficiaries (N = 816,245)



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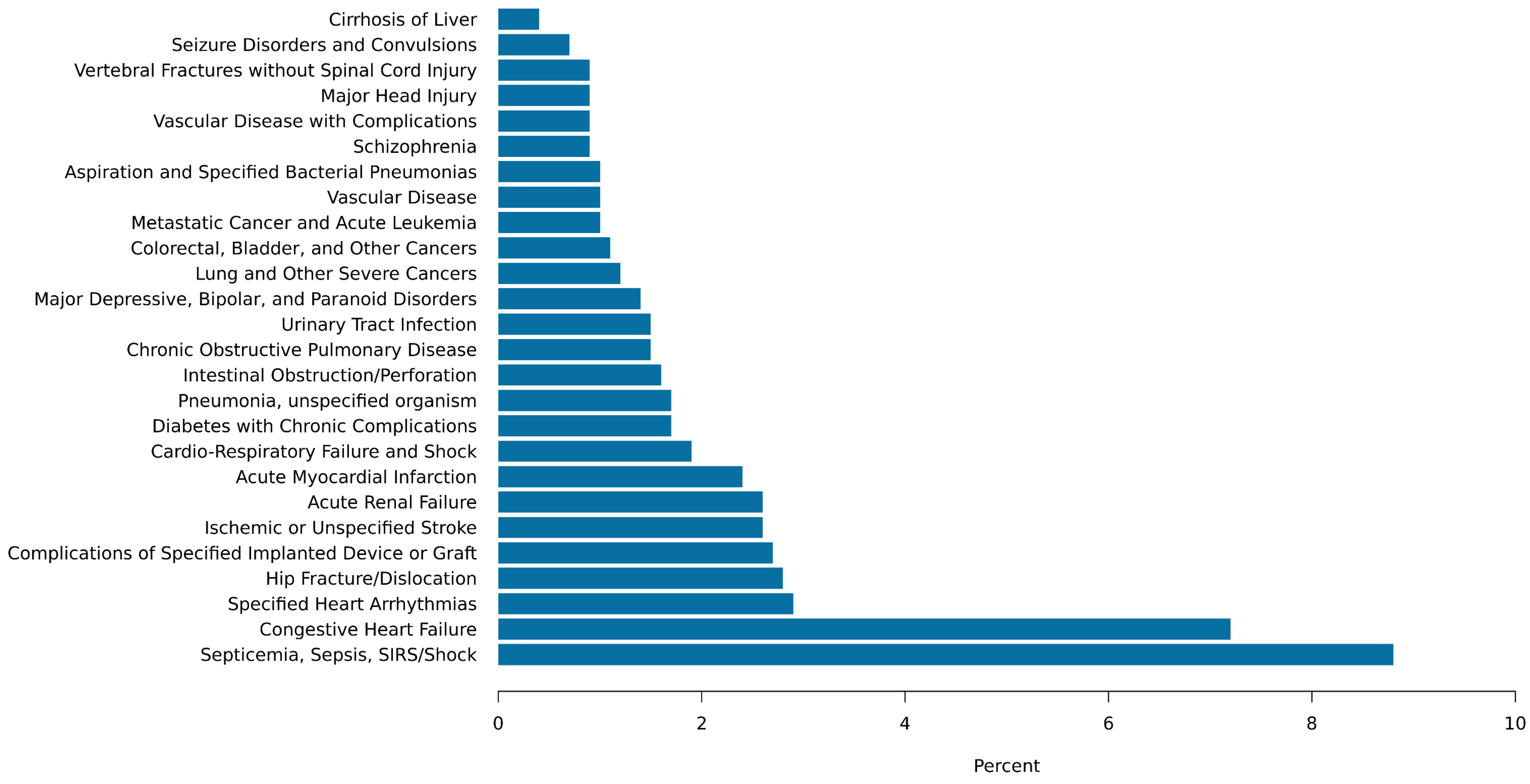
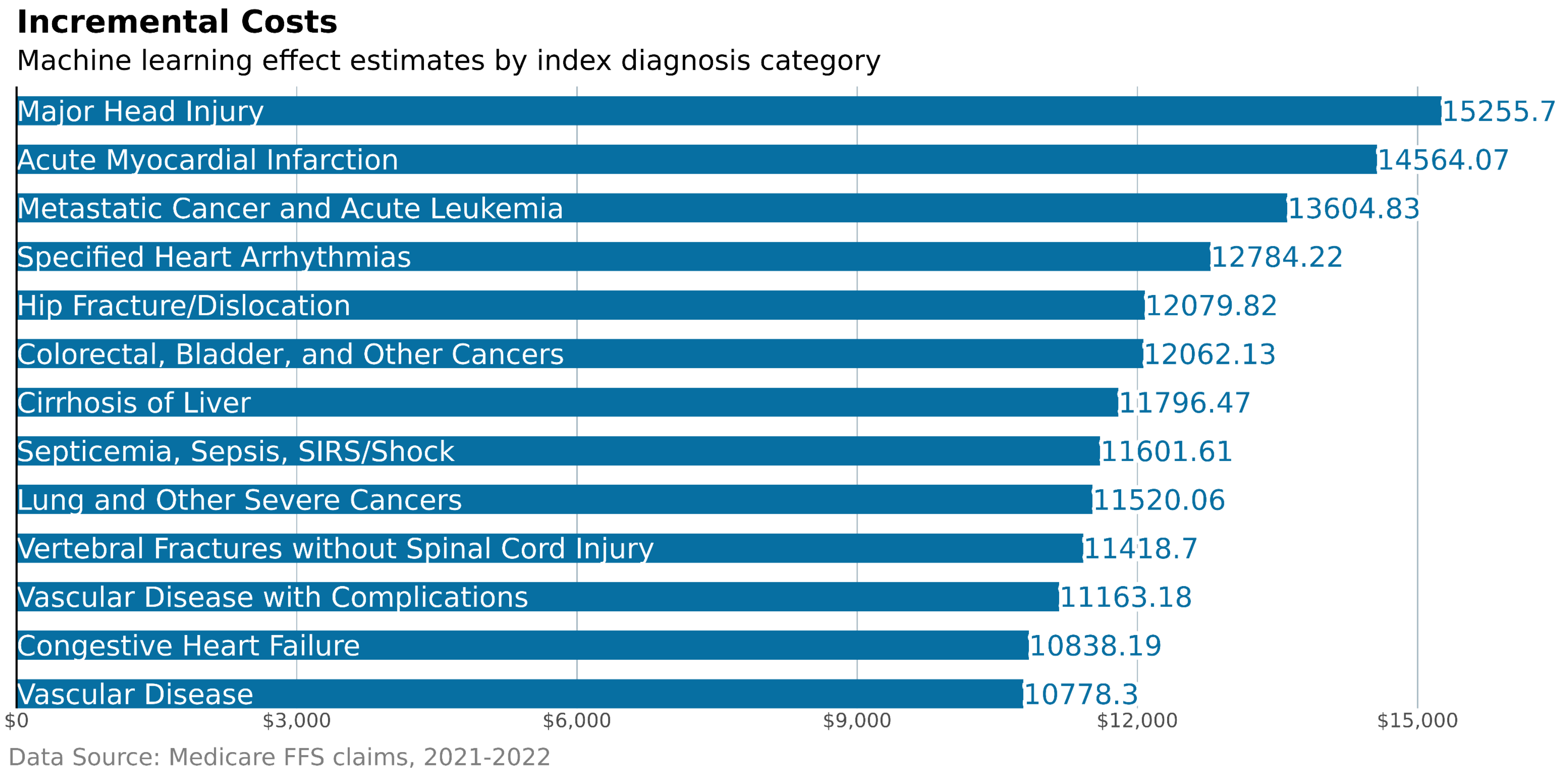
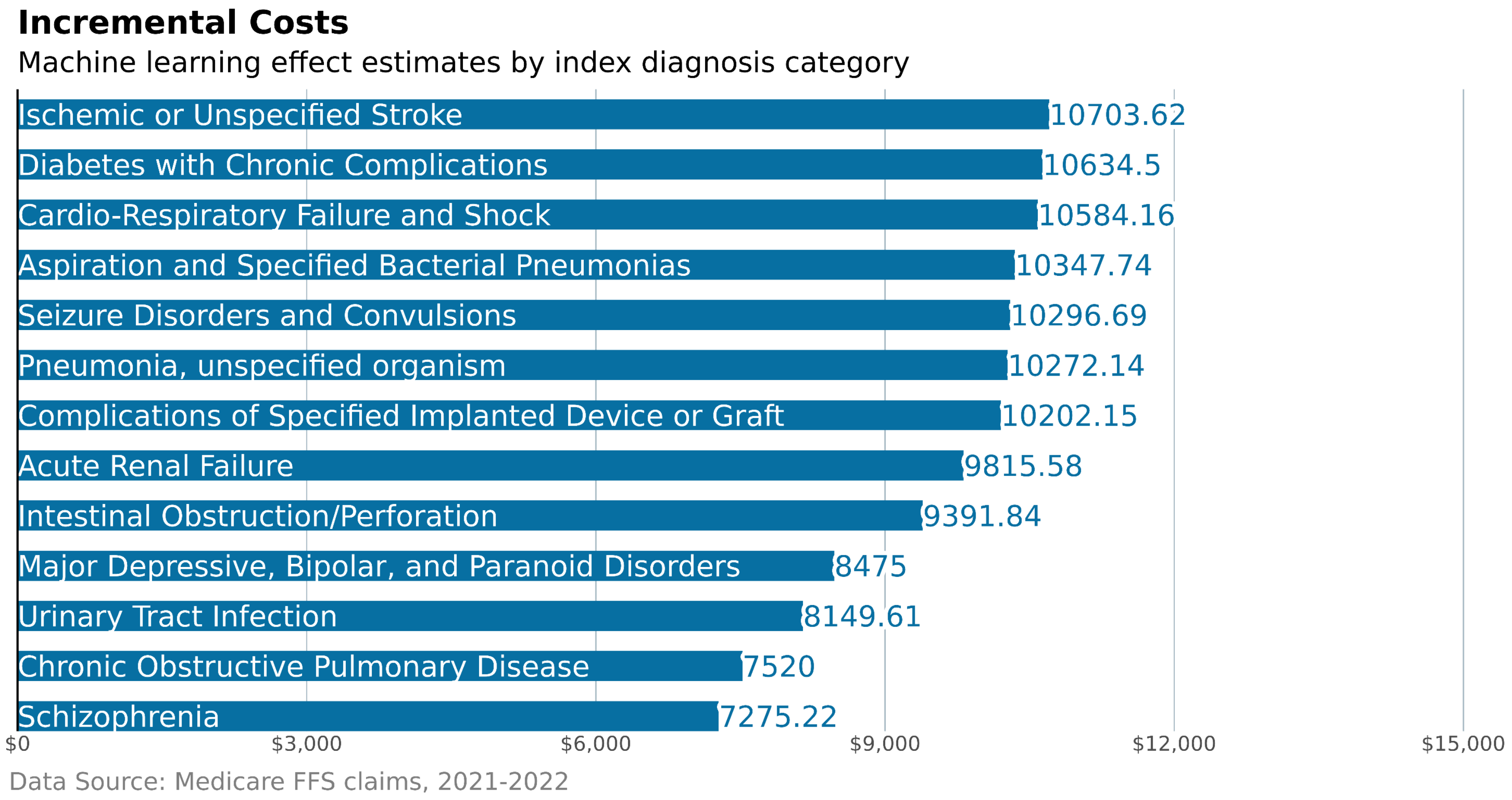
# Figure 2. Percent of hospitalized beneficiaries by hierarchical condition category (N = 434,665)



# Figure 3. TMLE estimates of incremental costs of hospital readmission for index condition categories 1 - 13



# Figure 4. TMLE estimates of incremental costs of hospital readmission for index condition categories 14 - 26



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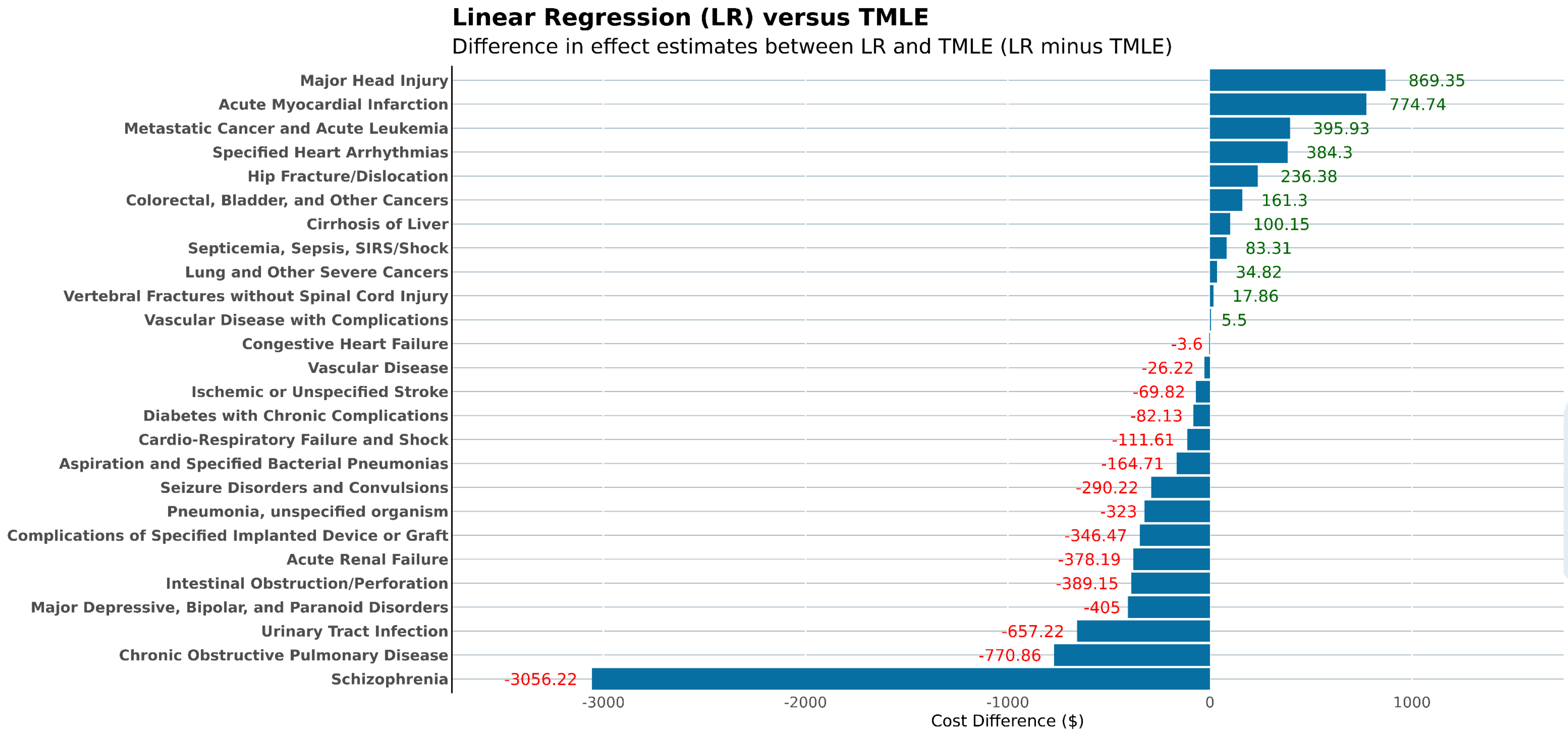
# Figure 5. Difference in cost estimates from linear regression versus TMLE models




Data Source: Medicare FFS claims, 2021-2022

# A General Approach to Return on Investment Valuation

- Savings on avoiding ***readmissions***:

$$\emptyset = \boldsymbol{E}_{W,M^{-}}[\boldsymbol{E}(\boldsymbol{Y} \backslash \boldsymbol{A} = \mathbf{1}, \boldsymbol{R} = \mathbf{1}, \boldsymbol{W}, \boldsymbol{M}^{-}) - \boldsymbol{E}(\boldsymbol{Y} \backslash \boldsymbol{A} = \mathbf{1}, \boldsymbol{R} = \mathbf{0}, \boldsymbol{W}, \boldsymbol{M}^{-})]$$

- Savings on avoiding ***ED Superutilizers***

$$\emptyset = \boldsymbol{E}_{W,M^{-}}[\boldsymbol{E}(\boldsymbol{Y} \backslash \boldsymbol{S} = \mathbf{1}, \boldsymbol{W}, \boldsymbol{M}^{-}) - \boldsymbol{E}(\boldsymbol{Y} \backslash \boldsymbol{S} = \mathbf{0}, \boldsymbol{W}, \boldsymbol{M}^{-})]$$

- Savings on avoiding ***Adverse Drug Events***

$$\emptyset = \boldsymbol{E}_{W,M^{-}}[\boldsymbol{E}(\boldsymbol{Y} \backslash \boldsymbol{E} = \mathbf{1}, \boldsymbol{W}, \boldsymbol{M}^{-}) - \boldsymbol{E}(\boldsymbol{Y} \backslash \boldsymbol{E} = \mathbf{0}, \boldsymbol{W}, \boldsymbol{M}^{-})]$$

# Conclusion

- There appears to be a need for a more robust approaching to the valuation of the incremental cost of hospital readmissions
- Current methods may not be capturing the ***true*** estimate (i.e., unbiased)
- Thus cost or return on investment valuations related to hospital readmissions may be understated or overstated
- Perhaps unsurprisingly, we note that the average incremental cost of a schizophrenia readmission was undervalued by over $3000 in the parametric model
- Previous literature demonstrated that mental health and substance use disorders are substantially undercompensated in the current Marketplace risk adjustment system (McGuire 2016; Montz et al. 2016)

# Authors

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# Appendix:
# ICD-10 to HCC classification

| ICD-10-CM codes | HCC category description |
|---|---|
| B20, B97.35, Z21 | HIV/AIDS |
| A02.1, A20.7, A22.7, A26.7, A32.7, A39.2-A39.4, A40.-, A41.-, A42.7, A48.3, A54.86, B00.7, B37.7, P36.-, R57.1, R57.8, R65.1-, R65.2-, T81.12XA | Septicemia, sepsis and systemic inflammatory response syndrome/shock |
| A07.2, A31.0, A31.2, B25.-, B37.1, B37.7, B37.81, B44.0-B44.7, B44.89, B44.9, B45.-, B46.-, B48.4, B48.8, B58.2, B58.3, B59 | Opportunistic infections |
| C77.0-C77.2, C77.4-C77.8, C78.-, C79.00-C79.72, C79.89, C79.9, C7B.-, C80.0, C91.0-, C92.00-C92.02, C92.40-C92.A2, C93.0-, C94.00-C94.22, C94.40-C94.42, C95.0- | Metastatic cancer and acute leukemia |
| C15.-, C16.-, C17.-, C22. -, C23, C24.-, C25.-, C33, C34.-, C38.4, C45.-, C48.-, C90.00-C90.22, C92.10-C92.32, C92.9-, C92.Z-, C93.10-C93.92, C93.Z-, C94.30-C94.32, C94.80-C94.82 | Lung and other severe cancers |
| C40.-, C41.-, C46.-, C47.-, C49.-, C56.-, C57.00-C57.4, C58, C70.-, C71.-, C72.-, C74.-, C75.1-C75.3, C77.3, C77.9, C79.2, C79.81, C79.82, C81.-, C82.-, C83.-, C84.-, C85.-, C86.-, C88.2-C88.9, C90.3-, C91.-, C95.10-C95.92, C96.- | Lymphoma and other cancers |

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# Engaging Partners and Communities

TMF Quality Innovation Network-Quality Improvement Organization

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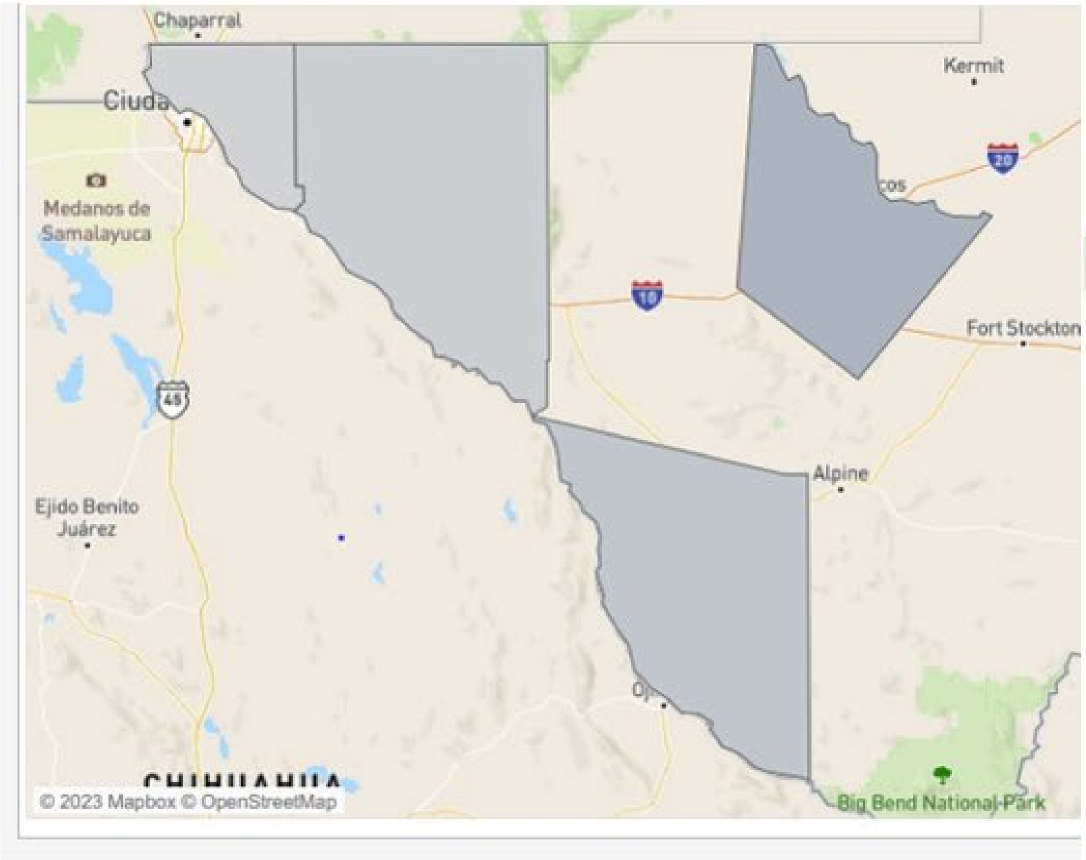
# Partnership for Community Health – El Paso, Texas Community

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# Facilitated Conversation: Coordination of Care Barriers

- Creative Brainstorming
  - Discharge follow-up to ensure primary care physician follow-up
  - Communication – find the right contact
  - Medication reconciliation
  - Transfer of information between providers
  - Downstream access to electronic medical records
  - Streamline education and make it consistent
  - Nurse-to-nurse handoff

# Multi-Voting: Coordination of Care Barriers

Top results:

- Need nurse-to-nurse handoff
- Need transfer of information between providers

**Identified transfer of information between providers as the main barrier**

# El Paso Nurse-to-Nurse Handoff Affinity Team: Leadership Organizing Actions

- **We,** *the El Paso Nurse-to-Nurse Handoff affinity team...*
- **Are organizing with** the El Paso community providers…
- **To** improve patient care coordination
- **By** having a nurse-to-nurse handoff report at transitions of care to improve the communication standard developed within this group of providers
- **In order to** reduce avoidable readmissions by 6% and adverse drug events by 2%
- **By** the end of December 2018

Resource: Originally adapted from a report by Ella Auchincloss, ReThink Health; modified by Kate B. Hilton, ReThink Health © Fannie E. Rippel Foundation, 2016.
https://tmfnetworks.org/link?u=39bf5f

# Partnership for Community Health – El Paso, Texas Community Readmission Data

**Baseline 30-day Readmission Rate**

**40.92%**

**Current 30-day Readmission Rate**

**25.05%**

**+38.8%**
**Relative Improvement Rate**

# El Paso Nurse-to-Nurse Handoff Affinity Team: Action Steps

**Affinity Team Meetings**

- The El Paso Nurse-to-Nurse Handoff Affinity Team meeting was held monthly using Re-Think Health and Leadership and Organizing in Action.

**Technical Assistance (TA)**

- The TMF Quality Innovation Network provided TA to help the affinity team review care transition information and make needed updates.

**Resources**

- The affinity team created the Nurse-to-Nurse Handoff/Transfer Report.
- The Joint Commission released 8 Tips for High-quality Hand-offs. Scan the QR code to download it.

# Refining the Nurse-to-Nurse Handoff/Transfer Report

- Testing
- Barriers
- Solutions

# Nurse-to-Nurse Handoff/Transfer Report

## Nurse to Nurse Handoff/Transfer Report

When transferring a patient, this checklist can be used between a patient's current and receiving caregiver. If the facility's process is to send information electronically, this sheet can be used as a checklist for the electronic form. Note: The essential items to send, according to The Joint Commission, are in red.

Handoff Report Nurse: ________ Reporting Nurse Contact Number: ________
Receiving Nurse: ________ Receiving Nurse Contact Number: ________

**Situation**
Reason for admission to facility:

Patient Name: ________ DOB: ________ Date: ________
Facility Name: ________ Unit: ________ Attending Physician: ________
Consultants: ________ Dates of Hospitalization: ________
Influenza Vaccine Received: ☐ Yes ☐ No Date: ________ Pneumococcal ☐ Yes ☐ No Date: ________
Admitting Diagnosis: ________ History of Present Illness: ________
Discharge Diagnosis: ________ Discharge Physician: ________
Choose Mode of Discharge Transportation to Home/SNF/LTAC: ☐ Self ☐ Caregiver ☐ Ambulance

**Background**

Age: ________ ☐ Male ☐ Female Language: ________ Communication Needs: ________
Past Medical History: ☐ Anxiety ☐ Anticoagulant/Reason: ________ ☐ AFIB ☐ DVT/PE
☐ Mech Valve ☐ Low EF: ________ Current Coumadin Dose: ________ Last PT INR Result: ________
Next PT INR Due: ________ Physician Ordering PT INRs: ________
History of: ☐ Arthritis ☐ Asthma ☐ CVA ☐ Alzheimer's ☐ CAD ☐ Cancer: Type: ________ ☐ CHF
☐ Chronic Pain ☐ COPD ☐ CKD ☐ Defibrillator ☐ Dementia ☐ Depression ☐ Diabetes ☐ Fall Risk ☐ GERD ☐ Hypertension
☐ Dialysis: ________ Days: ________ Time: ________ Place: ________
Cath Type: ________ ☐ Osteoporosis ☐ Pacemaker ☐ Seizures ☐ Liver Disease
Surgical History: ________
Post Op: Surgical Location: ________ Surgeon: ________
Advanced Directives: ☐ Yes ☐ No Code Status: ☐ Full Code ☐ DNR
Primary Caregiver Contact: ________ Phone: ________

Patient Name: ________ DOB: ________

**Assessment**
Illness and Severity

Date of Most Recent V/S: ________ Temp: ________ BP: ________ HR: ________ RR: ________
O2 Sat : ________ D/C Weight: ________ Pain Rating: ________ ☐ Pain Site: ________
☐ Pain Med/Last Dose: ________ Pain RX Sent? ☐ Yes ☐ No Pharmacy: ________
Last Blood Sugar Results: ________ Cardiac Rhythm: ________ Current Edema Status: ________
Hemiplegia: ☐ Yes ☐ No ________ Side Affected: ________ Lung Sounds: ________
☐ Bladder Incontinence Foley: ☐ Yes ☐ No Cath Insertion Date: ________ ☐ Bowel Incontinence
☐ Ostomy Date of Last BM: ________ ☐ Bowel Sounds ☐ Normal ☐ Hyper ☐ Hypo
Mental Status: ☐ Alert ☐ Disoriented ☐ X1 ☐ X2 ☐ X3 ☐ Agitated ☐ Forgetful ☐ Comatose
Diet: ________ Consistency: ________ ☐ Fluid Restriction: ________
Eats: ☐ Self ☐ With Assistance ☐ Difficulty Swallowing ☐ Aspiration Precautions
Tube Feeding Product: ________ ________ cc/every ________ hours ☐ Salem Sump ☐ Kaofeed
☐ G-Tube ☐ J-Tube Date Inserted: ________ * Free Water Bolus ________ cc every ________ hours
Infection: ☐ MRSA ☐ E-Coli ☐ C-Diff ☐ VRSA ☐ Hep C ☐ Staph ☐ VRE ☐ HIV ☐ Other: ________
Isolation Precautions: ☐ Yes ☐ No ________ ☐ PICC ☐ PICC Measurements: ________
☐ Porta Cath Accessed Date: ________ Antibiotic/Dose/Duration: ________ End Date: ________
Last Dose Time Given: ________ ☐ Heplock ☐ CVL TPN ☐ Yes ☐ No ☐ JP Drain ☐ Penrose Drain
Skin Care: ☐ No Skin Breakdown ☐ Pressure Ulcer: Stage: ________ Location: ________
☐ 2nd Pressure Ulcer Stage: ________ Location: ________ ☐ Wound Care Orders
☐ Wound Vac Rate: ________ mm/Hg ☐ Intermittent ☐ Continuous ☐ Foam Color: ________
Date Last Wound Vac Dressing Changed: ________ Discharge Condition: ________
☐ Sent Wound Care Orders ☐ Sent Last Wound Care Note ☐ Supplies: ________

**Recommendations**
To-Do Action List

DME Needed: ☐ Hospital Bed ☐ Bariatric Bed ☐ W/C ☐ Walker ☐ Suction Setup ☐ Nebulizer ☐ Ventilator Settings
Mode: ☐ AC ☐ IMV ☐ C-Pap Rate: ________ TV: ________ FIO2: ________ PS: ________
PEEP: ________ ☐ Bi-Pap Settings: ________ Oxygen Liters/Min: ________ ☐ Nasal Cannula
☐ Mask ☐ Trach Trach Size: ________ O2%: ________ ☐ ET Tube DME Company: ________
Pending Follow-Up Appointments Date/Time: ________ Physician: ________
Pending Follow-Up Appointments Date/Time: ________ Physician: ________
Pending Follow-Up Appointments Date/Time: ________ Physician: ________
Pending Lab and Test Results: ________

Source: TMF Quality Innovation Network, Nurse to Nurse Handoff/Transfer Request, retrieved online at https://tmfnetworks.org/link?u=fc977a on 2/7/2024

# Care Coordination during the Pandemic – El Paso Community

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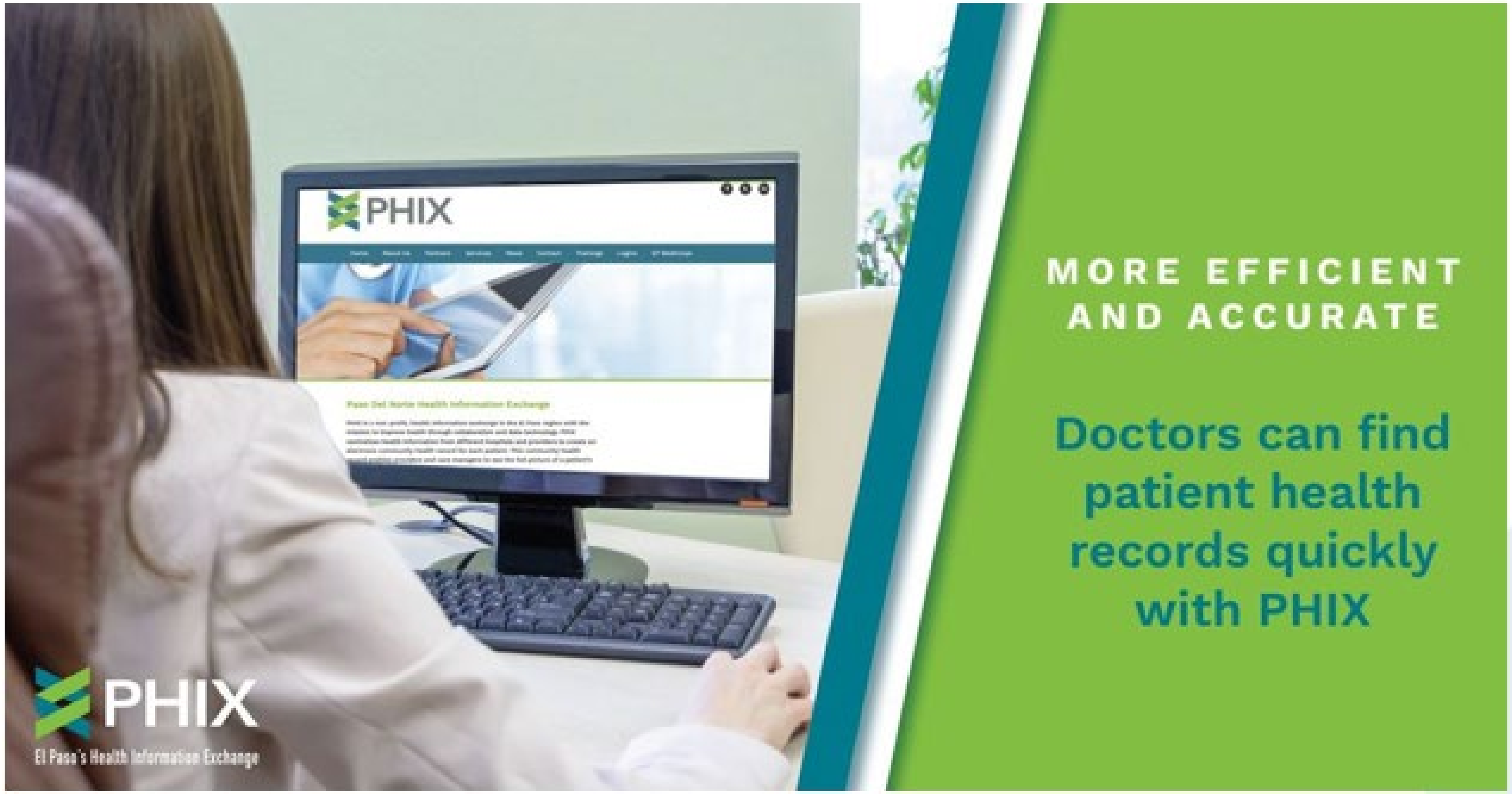
## El Paso COVID-19 Capabilities Assessment

In an effort to support and help facilitate care coordination communication for our El Paso COVID-19 Care Coordination Collaborative, **please complete the assessment in order to ensure the information is up-to-date and accurate.**

TMF will collect these updates and distribute them to the members of the El Paso COVID-19 Care Coordination Collaborative.

Thank you!

# El Paso Nurse-to-Nurse Handoff Affinity Team: Next Steps




Phase One

Phase Two

Phase Three

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# Conclusion