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DURATION VIEWS METHODOLOGY

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INTRODUCTION

A significant body of scientific evidence has shown that return-to-work and/or activity are associated with health benefits to the patient (Brassil, 2013). Understanding the expected path and time frame for returning to normal lifestyle may help providers set recovery goals for returning patients to normal living. With the Duration Views tool, MDGuidelines provides users with three unique perspectives of return to activity durations: the Physiological View, the Population View, and the Case View (including a newly enhanced predictive model). In this document, we will present the methodology behind developing these Duration Views.

PHYSIOLOGICAL VIEW

The **Physiological View** provides recommended disability durations that represent the physiological healing time for uncomplicated cases (herein called “physiological durations”). Developed by the MDGuidelines Medical Advisory Board, the physiological durations are based on clinical expertise and informed by real world claims. These physiological durations do not represent the absolute minimum or maximum lengths of disability at which an individual must or should return to work. Rather, they represent important points in time at which, if recovery has not occurred, additional evaluation (and possible intervention) should take place.

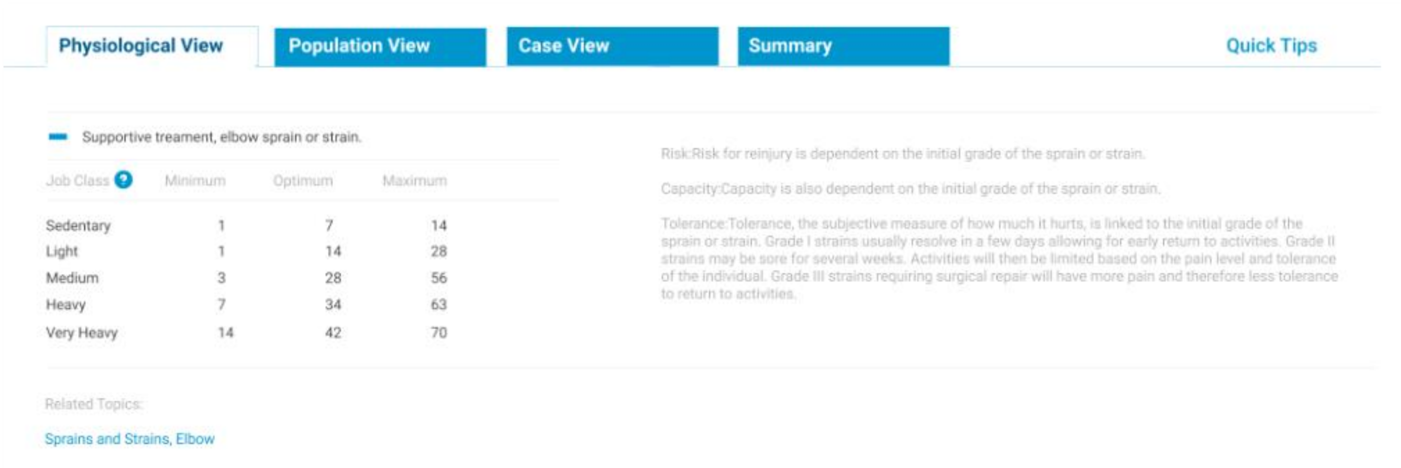

Figure 1. Example of Physiological View

PHYSIOLOGICAL DURATION TABLE DEVELOPMENT

MDGuidelines employs a two-step process in the development of the physiological duration tables. Using real-world case data and previously released physiological duration tables, the senior staff create statistical profiles that are reviewed and revised by a medical advisory board who apply their experience and research as a corrective, when necessary, to the statistical profiles. The evidence of the population data coupled with the consensus of expert medical practitioners provides an evidence-based, iterative process to create the physiological duration tables. This Modified Delphi approach combines the depth of MDGuidelines proprietary data with the breadth of expert medical judgment.

The first phase of the Modified Delphi approach involves a panel who flags and "corrects" durations that are skewed by factors such as selection bias. These "corrected" durations are subjected to the second phase of independent scrutiny. This scrutiny includes two levels of bias protection. First, a panel of experts must deliberate on the proposed ("corrected") durations—drawing solely upon their clinical experience and without recourse to the reference data. Thus, this group of experts does not merely replicate the steps established in the first phase. Instead, they approach the durations from another angle, with the result that any lingering discrepancies highlight the need further investigation. The second protection against bias occurs because this panel of experts operate independently of each other's input, insulating them from premature consensus.

The third phase requires a consolidation of professional opinions. The scrutinized and clinically modified durations are weighed against each other and against the reference data. This entire cycle is repeated when necessary. In this respect, duration guidelines follow the principles of evidence-based medicine: they result from clinical judgment and experience informed by statistical data, provide a baseline that is both humane and rigorous.

HOW TO INTERPRET PHYSIOLOGICAL DURATION TABLES

The physiological duration tables provide approximate return-to-activity timelines for injured or ill employees so that they can obtain the greatest health and productivity, according to physiological healing times. The physiological duration tables assume a) uncomplicated cases; and b) return to full duty.

Table 1. Example physiological duration table

JOB CLASS	MINIMUM	OPTIMUM	MAXIMUM
Sedentary	1	7	42
Light	3	14	42
Medium	14	21	56
Heavy	21	32	84
Very Heavy	28	48	91

While "return to full duty" is assumed in the physiological duration tables for consistency, in many cases the injured individual may return to activity in a restricted capacity. When activity is restricted, the exertion level of the new job description should be followed in the physiological duration tables. An employee may go out with a heavy exertion level but be brought back to a sedentary desk position.

The Physiological View provides minimum, optimum, and maximum recovery time by job classifications. These tables are most useful when envisioned as a continuum in the case management process. These values do not represent the absolute minimum or maximum lengths of disability at which an individual must or should return to work. Rather, they represent important points in time at which, if full recovery has not occurred, additional evaluation should take place.

You will find that some MDGuidelines physiological duration tables contain the term “indefinite”. This word implies the potential for an indefinite disability. In these cases, it is possible that a return to work may not be compatible at the same activity level.

In many physiological duration tables, five job classifications are displayed. These job classifications are based on the amount of physical effort required to perform the work. The classifications correspond to the Strength Factor classifications described in the United States Department of Labor’s *Dictionary of Occupational Titles*. The Department of Labor job classifications focus on physical effort only. This may not be relevant to the duration of some disabilities as many factors go into the length of disability.

POPULATION VIEW

The **Population View** provides summary statistics on disability durations drawn from the MDGuidelines Population Database of real-world disability records. These statistics include the frequency of conditions, their average lengths (herein called “population durations”), and the probability of return to full duty. The statistics in the Population View represent the actual observed experience of individuals across the spectrum of physical conditions, in a variety of industries, and with varying levels of case management. The Population View also reflects various psycho-social factors (e.g., individual’s motivation and benefit structure) that may affect return to normal activity. The Population View provides users with the ability to view the distribution (spread) of disability durations and measure their performance in maintaining a healthy population.

DATA SOURCES

The MDGuidelines Population Database includes more than seven million disability leave records for over 11,000 unique conditions (Figure 2) with information on length of time from date of absence to return to full duty, sex, age, job class (level of job exertion), and coexisting conditions. These records were provided to MDGuidelines from employers, insurers, healthcare providers, and government agencies. Both short-term disability and workers' compensation records were used for the Population View. The Population Database records are primarily from the United States (89%) across all 50 states (Figure 3).

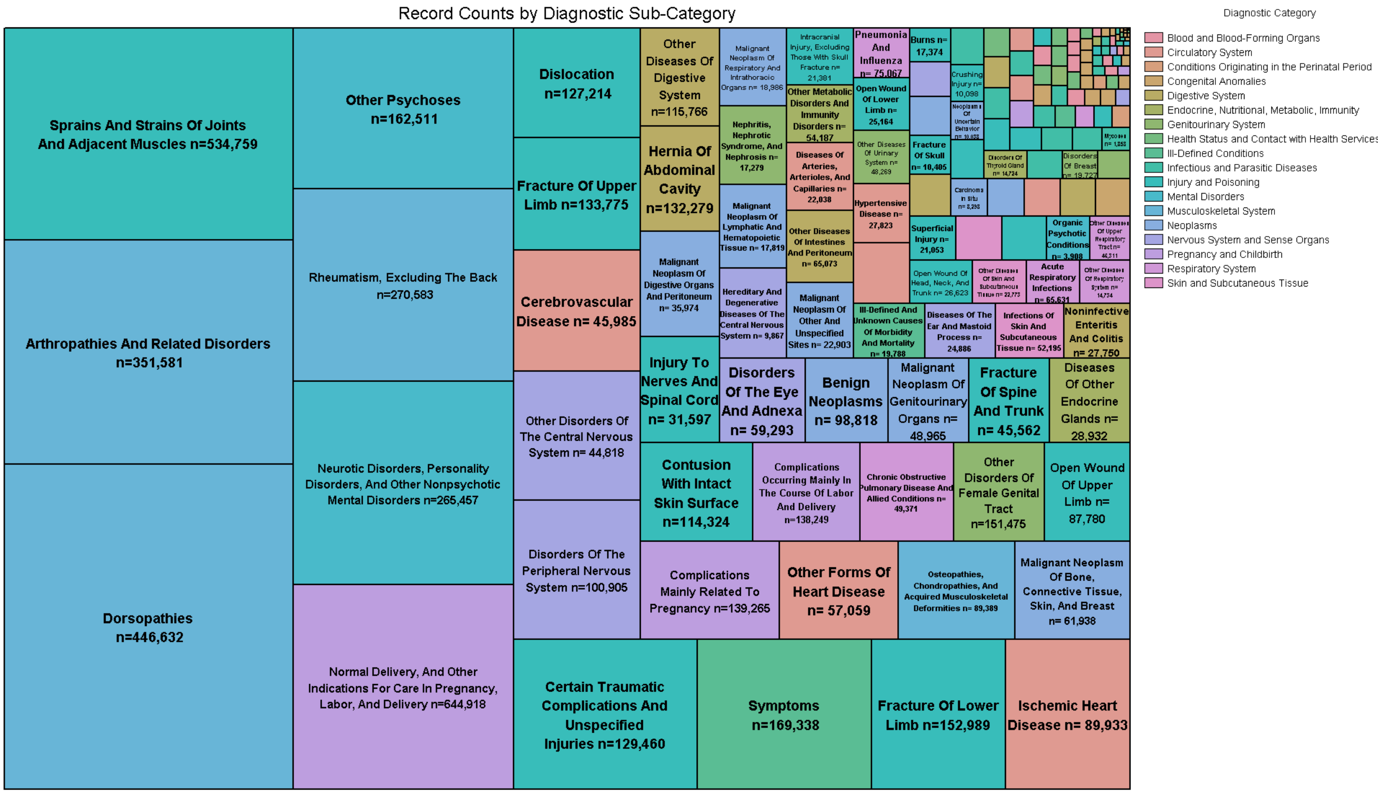

Figure 2. Breakdown of diagnostic sub-categories in Population Database. Colors indicate diagnostic category

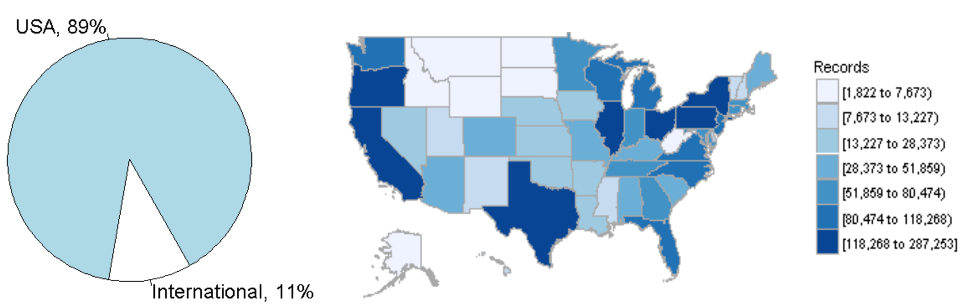

Figure 3. Geographic distribution of records in the MDGuidelines Population Database

DATA QUALITY ASSURANCE

Extensive data cleaning and validation is performed prior to using the data for any analysis. The following steps are part of the data quality assurance protocol:

1. Medical Code Validation Checks:
   a. Medical code is a valid, billable medical code
   b. Medical code corresponds to record's sex (e.g., remove records with obstetric diagnoses and male sex)
   c. Medical code corresponds to record's age (e.g., remove records with pediatric diagnoses)
2. Date Validation:
   a. A first absence date and a follow-up date. The follow-up date is typically the return to full duty date, but could also be the last date the record was tracked or the date the individual transferred from STD to LTD.
   b. Follow-up date is not before first absence date
   c. Follow-up date is not after receipt of data (e.g., return to work dates cannot be in the future)
3. Claim Demographics Validation:
   a. Perform previously mentioned medical code validation checks on record comorbidities
   b. Standardize variables across all data sets (i.e., all females mapped to "F" in sex column)

POPULATION VIEW STATISTICS

Diagnoses recorded with ICD-9-CM codes and ICD-10-CM codes were both used in the Population View, with ICD-10-CM codes mapped to ICD-9-CM codes for the model building process, using the Centers for Medicare and Medicaid general equivalency mapping (GEM) tables. When more than one possible ICD-9-CM code was appropriate to map for an ICD-10 code, we mapped the medical code to the most frequently observed in the database.

Typical to return-to-work (RTW) data, the MDGuidelines Population Database contains records for individuals that do not have a date specifying when the individual returned to full duty, but do have a follow-up date after their first absence date noting they were still on disability. There may be multiple reasons for this including that the individual never returned to full duty because they transferred to LTD, dropped out of the workforce, or died. A missing full duty date may also be because of incomplete data. However, since we have partial information of the time an individual was absent from work up until a certain point in time (called "right-censored" date in statistical terms), we must use this partial information and account for those individuals where we do not have a full duty date. If we do not account for those without a full duty date, we would bias the data towards only the most straightforward cases, those that left on a disability and returned to full duty.

To create a more accurate and complete Population View, we included information from all available records. In instances where we do not know what happened at the end of a case (did not return to full duty, died) we used a statistical method to utilize that information without giving it the same weight as a complete record. This statistical method, called a Kaplan-Meier estimation of the survival curve, was applied to STD and WC cases together to calculate the following duration statistics:

Table 2. Example Population View statistics table

Medical Code	Condition Frequency	Mean	Percentile					% Records with Durations > 365	% Records Returning to Full Duty
			5th	25th	Median	75th	95th		
S53.439A	High	150	10	27	69	167	590	6 %	87%

The definition of each statistic:

Condition Frequency = a field that describes the number of records by condition in the Population Database:

Low = 20 to 99 records
Medium = 100 – 499 records
High = 500+ records

Mean = the geometric mean of disability durations for the condition in the Population Database

5th %ile = the 5th percentile disability durations for the condition in the Population Database. For example, if there are 100 records for a medical code and the 5th percentile was ten days, five out of 100 records would have a disability duration of ten days or less.

25th %ile = the 25th percentile of disability durations for the condition in the Population Database. For example, if there are 100 records for a medical code and the 25th percentile was 32 days, 27 out of 100 records would have a disability duration of 27 days or less.

Median = the median or 50th percentile of disability durations for the condition in the Population Database. For example, if there are 100 records for a medical code and the median was 69 days, 50 out of 100 records would have a disability duration of 69 days or less.

75th %ile = the 75th percentile disability durations for the condition in the Population Database. For example, if there are 100 records for a medical code and the 75th percentile was 167 days, 75 out of 100 records would have a disability duration of 167 days or less.

95th %ile = the 95th percentile disability durations for the condition in the Population Database. For example, if there are 100 records for a medical code and the 95th percentile was 590 days, 95 out of 100 records would have a disability duration of 590 days or less.

% of Records with Durations > 365 = The percentage of records where the disability duration exceeded 365 days.

% of Records Returning to Full Duty = The percentage of records that returned to full duty within the follow-up time (transferred to LTD from STD, dropped out of work force, etc.).

Note: If a population statistic says "Indefinite", then the records at that percentile and above never returned to full activity and we cannot give a definitive duration. For example, if the 75th percentile says "Indefinite" then at least 25% of the records in the database for that condition did not return to full duty.

POPULATION VIEW HISTOGRAM

The distribution of durations in the Population View are presented using a histogram. Each bar represents the percent of the total records that are within a day range. For example, the leftmost bar in Figure 4 indicates that ~1% of the records returned from their disability leave between zero and five days after first absence date. In many cases, individuals transfer to long-term disability, drop out of workforce, or have another reason for not having a return to full duty date. We distinguish between those that return to full duty and those who do not with differently colored stacked bars.

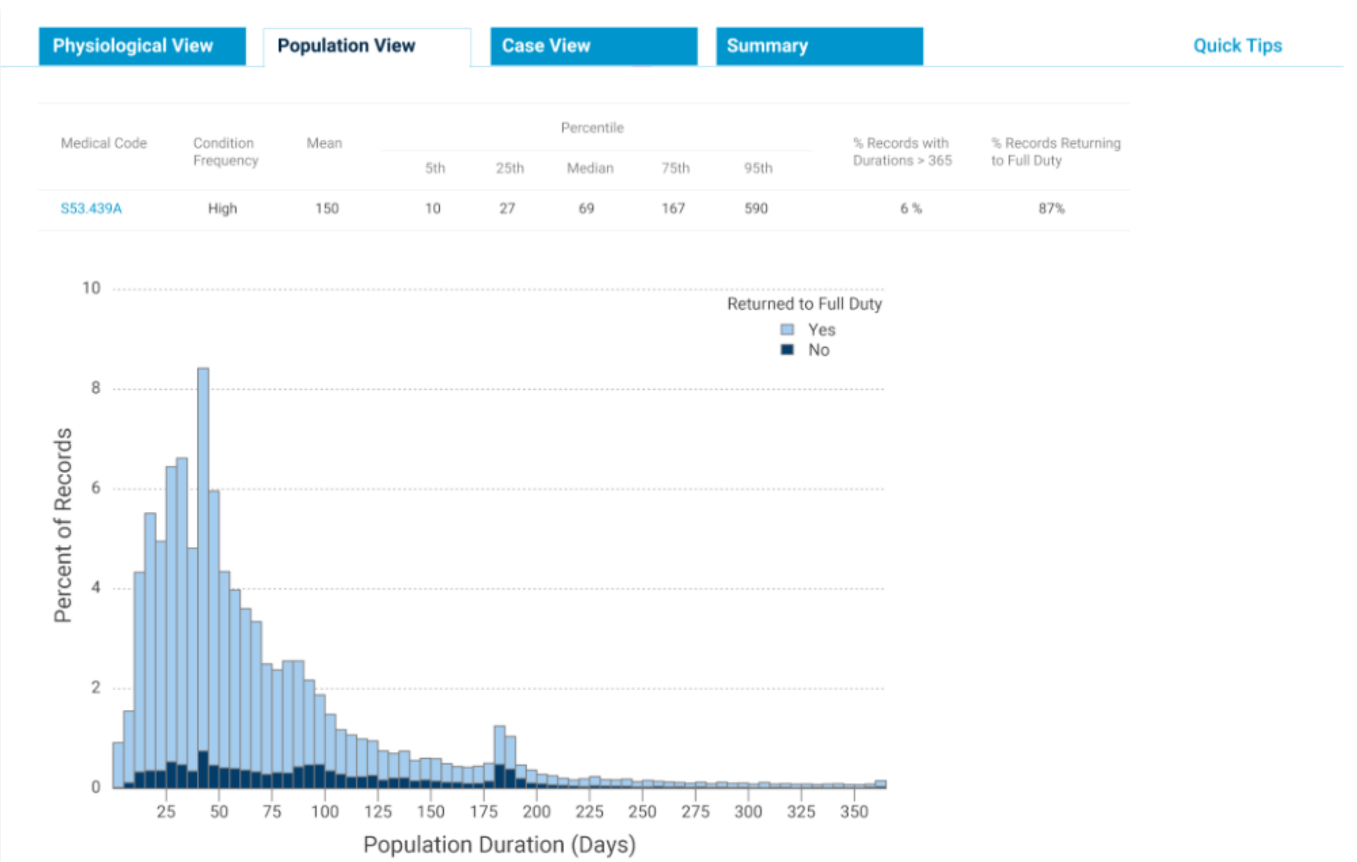

Figure 4. Example of a histogram displayed in Population View

CASE VIEW

The **Case View**, which includes a newly enhanced predictive model, predicts disability duration by medical condition (herein called "predicted case durations"). Used in retrospect, the information aids in the assessment of case handling. Used prospectively for complicated cases, the information shows cases that may require a higher level of triage. The predicted durations in the Case View take into account case-specific information using a machine-learning algorithm trained on records from the MDGuidelines Population Database.

DATA

The Case View developed predictive models using STD and WC records in the MDGuidelines Population Database. We excluded the following conditions as primary diagnoses in the models: conditions related to delivery and the perinatal period, procedures, external causes (E codes), and visit codes (V codes). Analysis was restricted to records from individuals 16 years and older. Finally, we removed all conditions where the disability duration was greater than two years. For disability durations with a zero duration, we randomly gave a duration between zero and one day (required when using a logarithmic model). After all exclusion criteria, the model used more than five million records.

POTENTIAL PREDICTORS

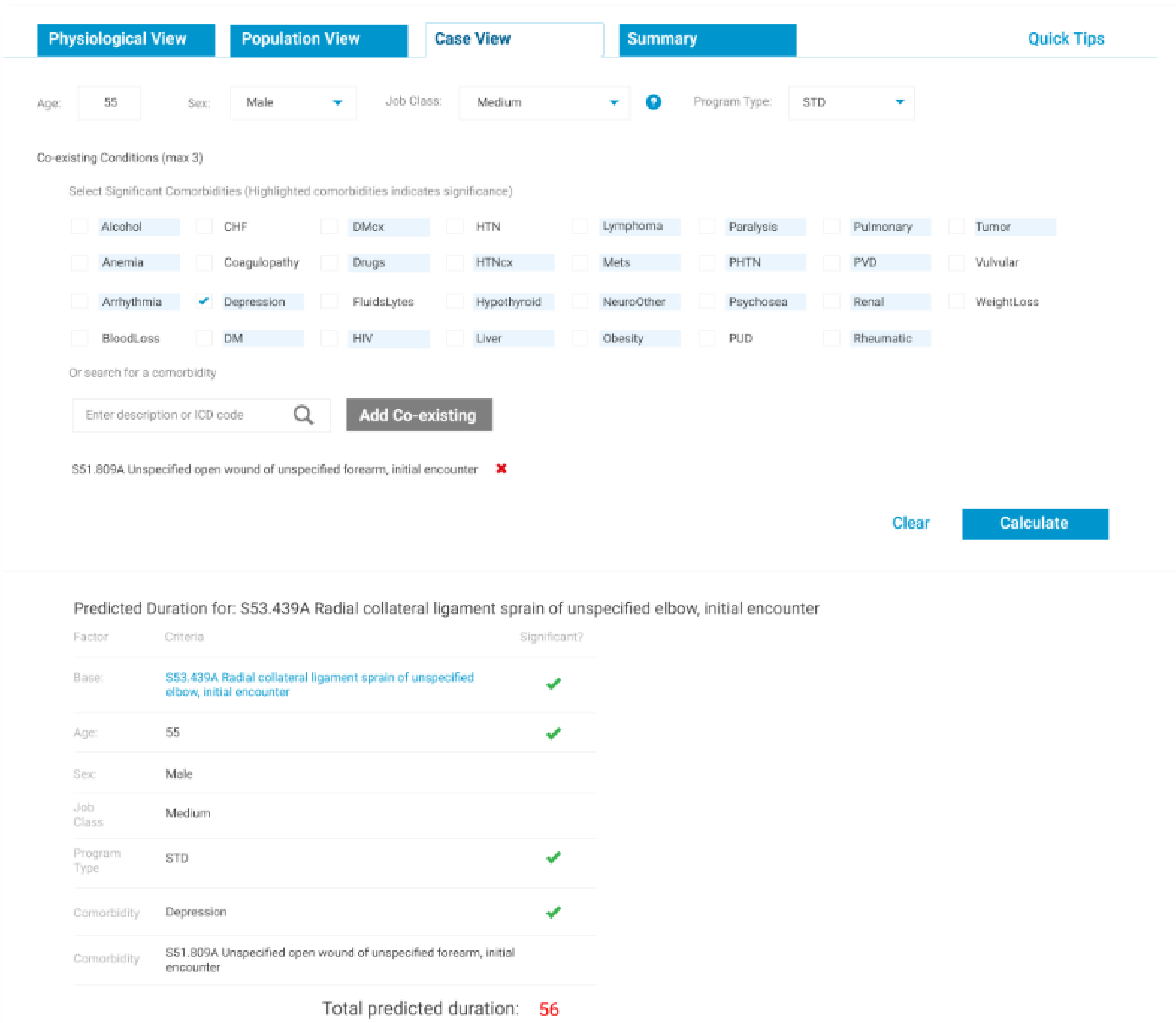

Figure 5. Example of Case View

The following variables were tested for their ability to predict disability duration:

1. Age in years
2. Sex (binomial, 0 = male, 1 = female)
3. Job class as defined by U.S. Department of Labor's Dictionary of Occupational Titles. The job classes include "Sedentary", "Light", "Medium", "Heavy", and "Very Heavy" work (ordinal variables).
4. Program type (binomial, 0 = STD, 1 = WC)
5. Coexisting conditions. Coexisting conditions that fit within comorbidity groupings as defined by Quan et al. (2005) were grouped (binomial, 0/1) and the individual ICD-9-CM codes within the groupings were removed. Additional coexisting conditions that did not fit within the comorbidity groupings were used individually as binomial variables within the model. A co-morbidity was only considered if there are at least ten records for that condition or the comorbidity grouping.

Variables missing data in more than 25% of the records per model were removed as potential predictors. Missing data for predictors (<25% missing) was imputed using the observed variable distribution.

STATISTICAL METHODS

To create predictive models, we used survival models to account for the right-censored records (individuals that do not return to full duty) in the data. We leveraged information across sub-classes of ICD-9-CM codes by building a model for each sub-class with specific conditions represented by indicator variables (binomial-yes/no). For example, ICD codes related to venous embolism and thrombosis (ICD-9-CM codes starting with 453) were analyzed in a single model. As an illustration, say the disability records contain 75 records with Budd-Chiari syndrome (ICD-9-CM = 453.0) and 25 records of thrombophlebitis migrans (ICD-9-CM = 453.1), all 100 records would be used in the survival model with two indicator variables (binomial, 0/1) indicating whether the individual had ICD-9-CM = 453.0 or 453.1. Further, if the number of records in a particular sub-class were less than 40, we combined all the conditions within a diagnostic subcategory to build the model, also only using if more than 40 records. The advantage of grouping similar conditions together is that we have more statistical power to detect associations between demographic predictors (e.g., age, sex) and RTW durations. Individual indicator variables for the specific ICD-9-CM were also only included if at least 20 records were present.

We used the least absolute shrinkage and selection operator method (Lasso) method with a Cox-Proportional Hazard kernel to determine the predictors of the prognostic model (Tibshirani, 1997). Using 10-fold cross-validation, the Lasso method penalizes the negative log of the partial likelihood across a range of values for a regularization parameter (lambda). The final model and selected predictors were chosen using the largest value of lambda such to minimize the error. This procedure was implemented using the *cv.glmnet* function from the glmnet package (Friedman, Hastie, & Tibshirani, 2010; Simon, Friedman, Hastie, & Tibshirani, 2011) using R version 3.3.1 (R Core Team, 2016). Figure 6 illustrates cross-validation and how Lasso picks significant predictors.

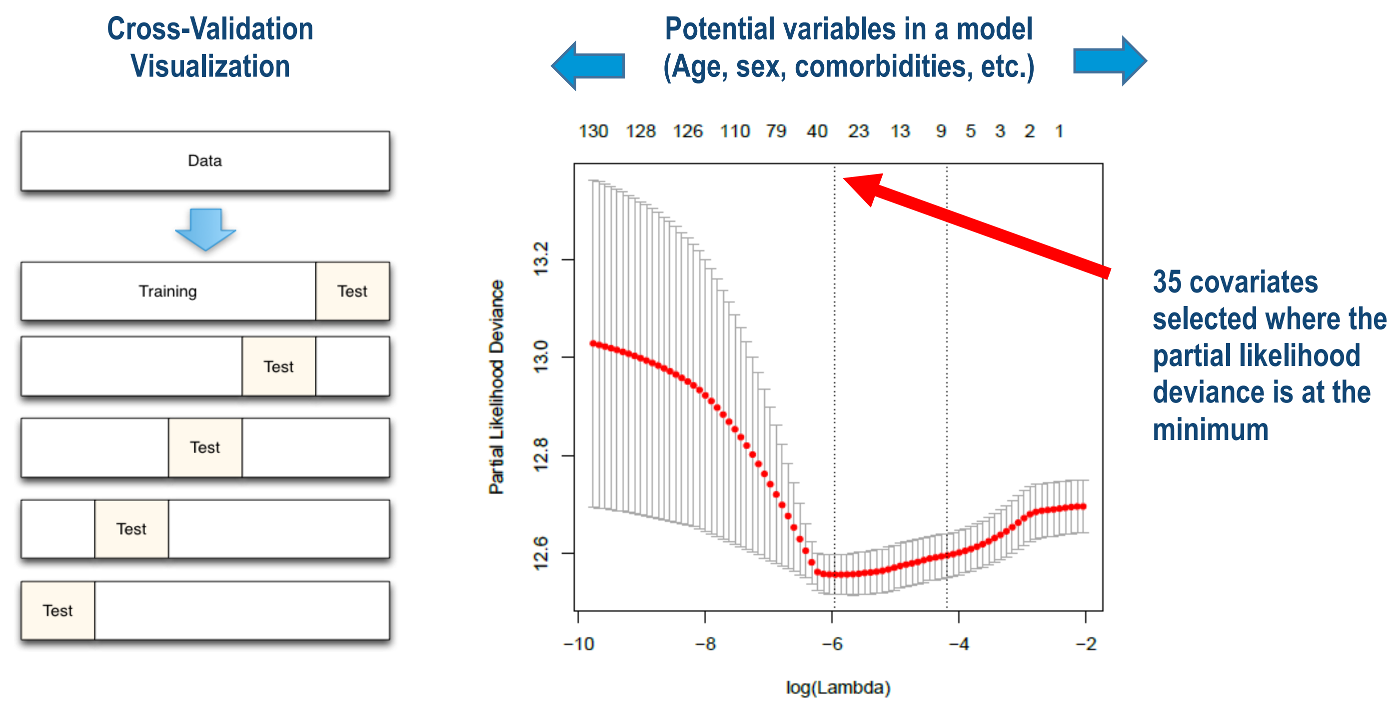

Figure 6. Example of Lasso cross-validation and variable selection. The left figure illustrates how the data set is repeatedly split into a training and test, where a model is built in the "training" set and the performance is checked in the "test" set. The right figure illustrates that cross-validation is applied across different combinations of variables and the final model is selected as the combination of variables that produces the minimum prediction error.

The population durations generally followed a log-normal distribution more closely than a gamma or exponential distribution; therefore, we input the significant predictors from the lasso procedure into a log-normal parametric survival model to predict case durations. To further optimize the models, we performed a backward stepwise regression procedure removing variables with a p-value > 0.2. Finally, if a comorbidity grouping or individual coexisting condition reduced the total predicted case duration (protective effect), we removed that condition assuming that coexisting conditions should not theoretically improve prognosis.

EXPLANATION OF CASE VIEW RESULTS

Predicted Duration for: S53.439A Radial collateral ligament sprain of unspecified elbow, initial encounter

Factor	Criteria	Significant?
Base:	S53.439A Radial collateral ligament sprain of unspecified elbow, initial encounter	✔
Age:	55	✔
Sex:	Male	
Job Class	Medium	
Program Type	STD	✔
Comorbidity	Depression	✔
Comorbidity	S51.809A Unspecified open wound of unspecified forearm, initial encounter	

Total predicted duration: 56

Figure 7. Example of Case View results

- Factor = the variable used to predict duration in the model.
- Criteria = the input of each factor
- Significant = whether the factor significantly changes the predicted duration
- Total predicted duration = the output of the predictive model

SUMMARY TAB

The Summary tab allows the user to synthesize all three Duration Views and evaluate how their case compares with these views (Figure 8). We present some key duration milestones on a timeline: the physiological minimum, physiological optimum, physiological maximum, the population median, and the predicted case duration. In addition, the user can enter a start date for their case they want to compare to the milestones. The calculate days from the start date to the current day is then plotted on the timeline for easy comparison.

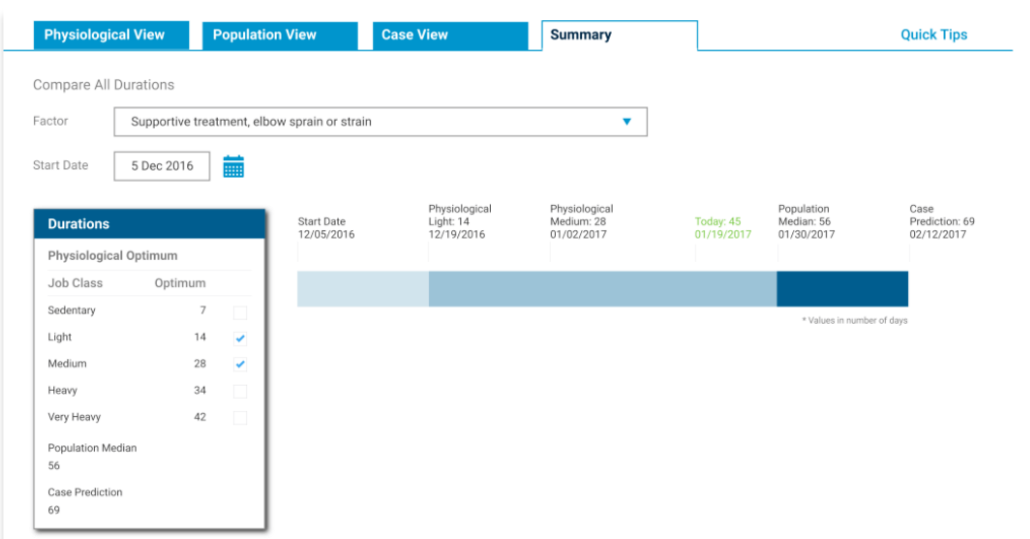

Figure 8. Example of milestone timeline in the summary tab

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