

How to Use CohortAlgebra R Package

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Contents

1	Introduction	1
1.1	Installation	1
1.2	Cohort UNION	2
1.3	InterSect Cohort	4
1.4	Minus Cohort	12
1.5	Modify Cohort	16
1.6	Remove subjects from Cohort	17

1 Introduction

(This package is NOT part of HADES.)

The idea behind this package is to allow the construction of new cohorts from previously instantiated cohorts in the cohort table. All cohorts in OHDSI have a standard definition: “A cohort is a set of persons who satisfy one or more inclusion criteria for a duration of time.”

- One person may belong to multiple cohorts
- One person may belong to the same cohort for multiple different time periods
- One person may not belong to the same cohort multiple times during the same period of time
- A cohort may have zero or more members

This is represented in a cohort table as `cohort_definition_id`, `subject_id`, `cohort_start_date` and `cohort_end_date`. For more details about the concept of a cohort please review The Book of OHDSI.

This package allows the creation of new cohorts from previously instantiated cohort table using cohort algebra (similar to temporal set algebra). The output is one or more new cohorts.

1.1 Installation

- This is an installable R-package that may be installed as follows:

```
remotes::install_github("OHDSI/CohortAlgebra")
```

```
#> Consider adding 'DATABASECONNECTOR_JAR_FOLDER='D:/windows_temp/AppData/Local/Temp/rtemp\RtmpsJ9eL0\j
#> DatabaseConnector postgresql JDBC driver downloaded to 'D:/windows_temp/AppData/Local/Temp/rtemp\Rtmp
```

1.2 Cohort UNION

- Given two or more cohorts, an UNION operator on these cohorts creates a new cohort with continuous days the persons was present in any of the cohorts. For example: given a cohort table as follows

cohort

```
#> # A tibble: 3 x 4
#>   cohortDefinitionId subjectId cohortStartDate cohortEndDate
#>           <dbl>       <dbl> <date>           <date>
#> 1             1         1 2022-01-01      2022-03-01
#> 2             2         1 2022-02-10      2022-05-10
#> 3             2         1 2022-08-15      2022-12-30
```

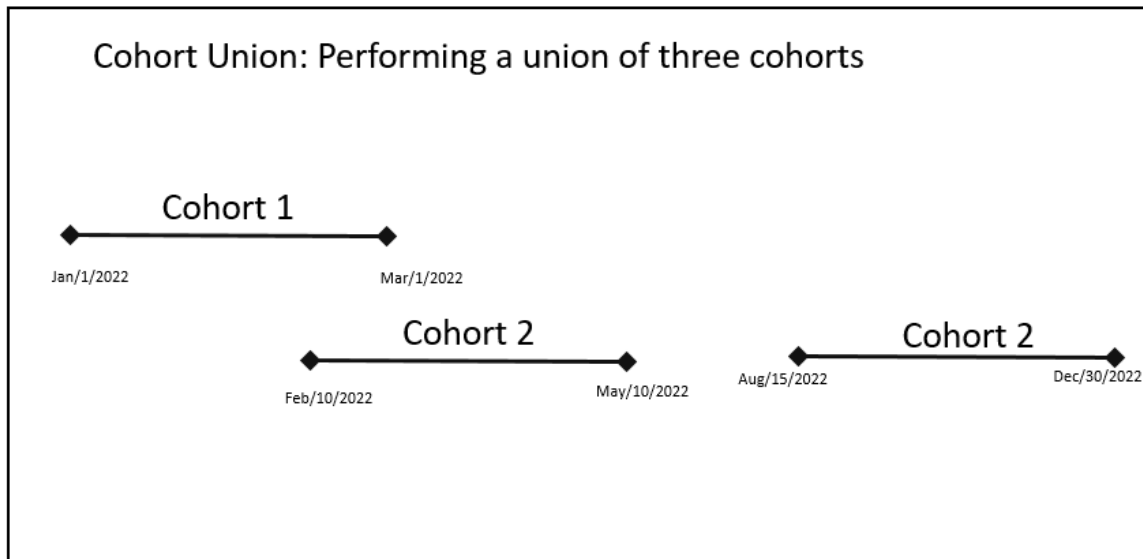
```
#> Connecting using PostgreSQL driver
```

The union of the two cohorts is expected to give us

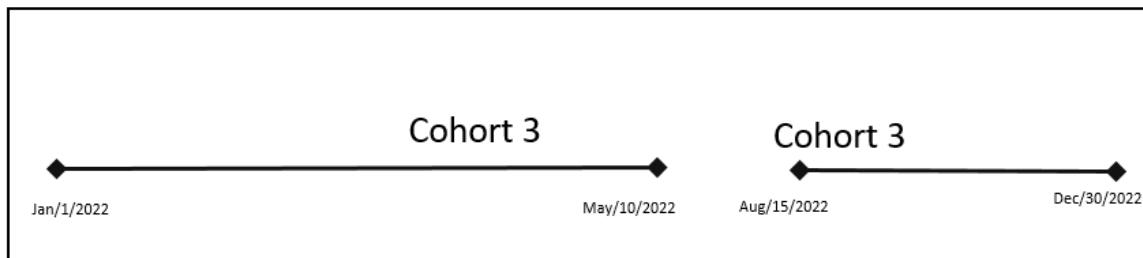
cohortExpected

```
#> # A tibble: 2 x 4
#>   cohortDefinitionId subjectId cohortStartDate cohortEndDate
#>           <dbl>       <dbl> <date>           <date>
#> 1             3         1 2022-01-01      2022-05-10
#> 2             3         1 2022-08-15      2022-12-30
```

Input



Output



To perform Cohort Union, we use the `unionCohorts` function. This function requires as an input a data.frame called `oldToNewCohortId`. Here we specify the cohort id's of the cohorts we want to union. The `newCohortId` is the cohortId of the resultant cohort. The `oldCohortId` are cohorts that are already in the cohort table.

```
oldToNewCohortId <-  
  dplyr::tibble(  
    oldCohortId = c(1, 2, 2),  
    newCohortId = c(3, 3, 3)  
  )  
  
CohortAlgebra::unionCohorts(  
  connection = connection,  
  sourceCohortDatabaseSchema = cohortDatabaseSchema,  
  sourceCohortTable = tableName,  
  targetCohortDatabaseSchema = cohortDatabaseSchema,  
  targetCohortTable = tableName,  
  oldToNewCohortId = oldToNewCohortId  
)
```

Now we will have a new cohortId '3' which is the union of cohortId's 1 and 2.

```
data
```

```
#> # A tibble: 2 x 4
#>   cohortDefinitionId subjectId cohortStartDate cohortEndDate
#>       <dbl>         <dbl> <date>         <date>
#> 1             3             1 2022-01-01     2022-05-10
#> 2             3             1 2022-08-15     2022-12-30
```

Note: if the target cohort table had a cohort with cohortId = 3, before running the union function - this would cause a conflict. In those cases, the union function would not run. We can purge all records for cohortId = 3 from the target cohort table. The parameter purgeConflicts will delete any cohort records in the cohort table where cohortId is the cohortId of the newCohort.

1.3 Intersect Cohort

- Given two or more cohorts, an INTERSECT operator on these cohorts creates a new cohort with continuous days the persons was present in ALL of the cohorts.

1.3.1 Intersect cohort example 1

Input:

```
cohort
```

```
#> # A tibble: 2 x 4
#>   cohortDefinitionId subjectId cohortStartDate cohortEndDate
#>       <dbl>         <dbl> <date>         <date>
#> 1             1             1 2022-01-01     2022-01-15
#> 2             2             1 2021-12-15     2022-01-30
```

```
CohortAlgebra::intersectCohorts(
  connection = connection,
  sourceCohortDatabaseSchema = cohortDatabaseSchema,
  sourceCohortTable = tableName,
  targetCohortDatabaseSchema = cohortDatabaseSchema,
  targetCohortTable = tableName,
  cohortIds = c(1, 2),
  newCohortId = 3
)
```

```
#> |
```

```
#> Executing SQL took 0.0157 secs
```

```
#> Intersecting cohorts.
```

```
#> Generating eras and saving.
```

Output

```
#> # A tibble: 1 x 4
#>   cohortDefinitionId subjectId cohortStartDate cohortEndDate
#>       <dbl>         <dbl> <date>         <date>
#> 1             3             1 2022-01-01     2022-01-15
```

Input



Output



Figure 1: Cohort Intersect 1

1.3.2 Intersect cohort example 2

Input:

```
cohort
```

```
#> # A tibble: 3 x 4
#>   cohortDefinitionId subjectId cohortStartDate cohortEndDate
#>       <dbl>         <dbl> <date>         <date>
#> 1             1             1 2022-01-01     2022-01-15
#> 2             2             1 2021-12-15     2022-01-05
#> 3             2             1 2022-01-10     2022-01-30
```

```
CohortAlgebra::intersectCohorts(
  connection = connection,
  sourceCohortDatabaseSchema = cohortDatabaseSchema,
  sourceCohortTable = tableName,
  targetCohortDatabaseSchema = cohortDatabaseSchema,
  targetCohortTable = tableName,
  cohortIds = c(1, 2),
  newCohortId = 3
)
```

```
#> |
```

```
#> Executing SQL took 0.0151 secs
```

```
#> Intersecting cohorts.
#> Generating eras and saving.
```

Output

```
#> # A tibble: 2 x 4
#>   cohortDefinitionId subjectId cohortStartDate cohortEndDate
#>       <dbl>         <dbl> <date>         <date>
#> 1             3             1 2022-01-01     2022-01-05
#> 2             3             1 2022-01-10     2022-01-15
```

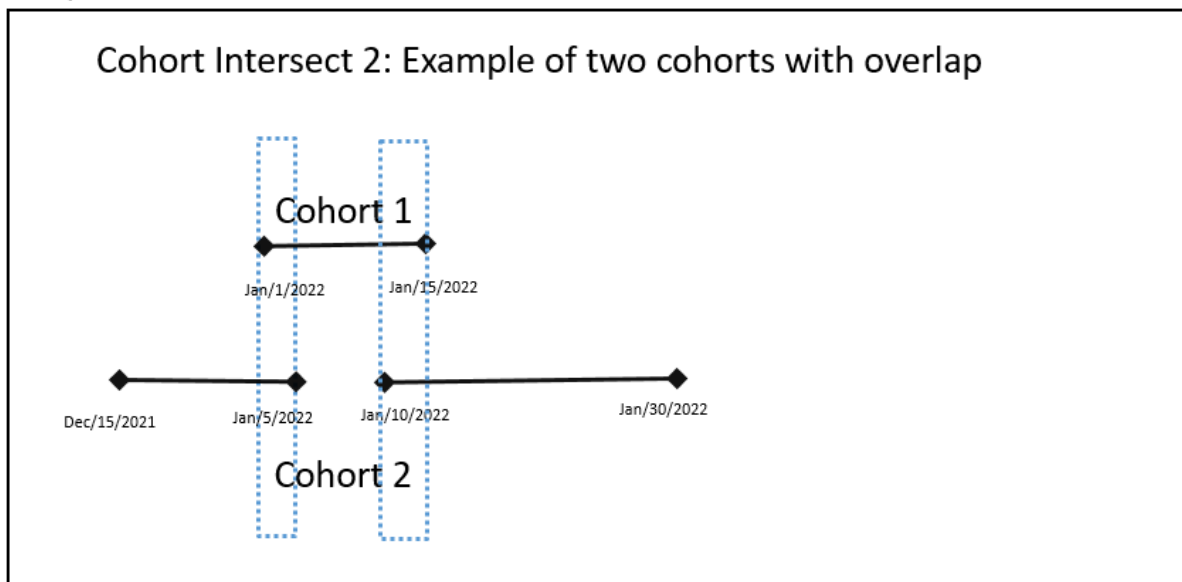
1.3.3 Intersect cohort example 3

Input:

```
cohort
```

```
#> # A tibble: 3 x 4
#>   cohortDefinitionId subjectId cohortStartDate cohortEndDate
#>       <dbl>         <dbl> <date>         <date>
#> 1             1             1 2022-01-01     2022-01-15
#> 2             2             1 2021-12-15     2022-01-30
#> 3             3             1 2022-03-01     2022-03-15
```

Input



Output



Figure 2: Cohort Intersect 2

```
CohortAlgebra::intersectCohorts(
  connection = connection,
  sourceCohortDatabaseSchema = cohortDatabaseSchema,
  sourceCohortTable = tableName,
  targetCohortDatabaseSchema = cohortDatabaseSchema,
  targetCohortTable = tableName,
  cohortIds = c(1, 2, 3),
  newCohortId = 4
)
```

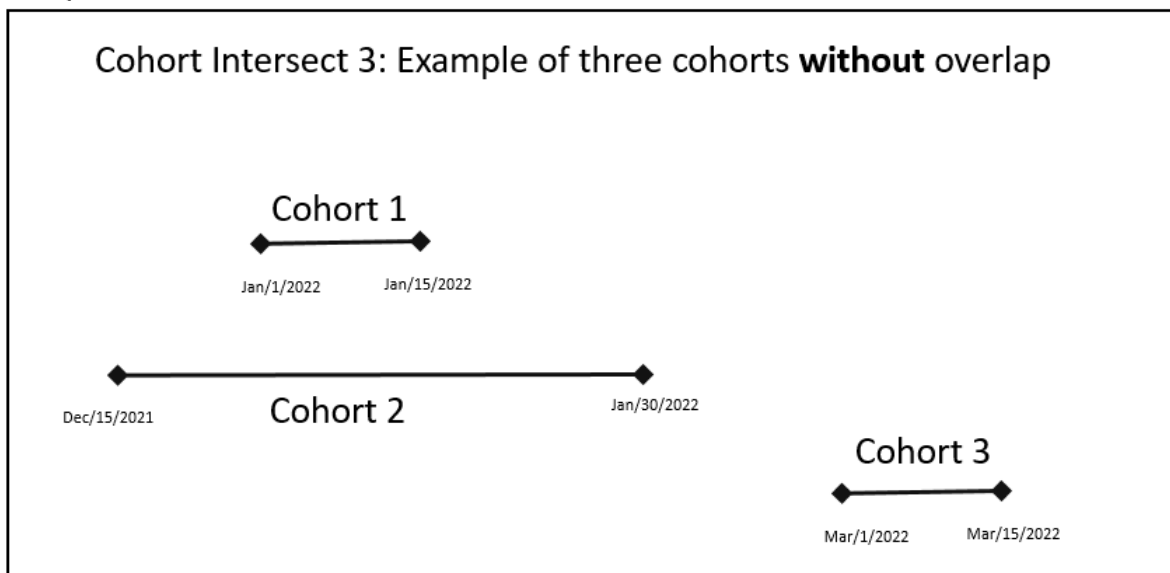
```
#> |
```

```
#> Executing SQL took 0.016 secs
```

```
#> Intersecting cohorts.
```

```
#> Generating eras and saving.
```

Input



Output

NULL Cohort – i.e. no cohort is created

Figure 3: Cohort Intersect 3

Output


```
data
```

```
#> # A tibble: 0 x 4  
#> # ... with 4 variables: cohortDefinitionId <dbl>, subjectId <dbl>, cohortStartDate <date>, cohortEndDate <date>
```

1.3.4 Intersect cohort example 4

Input:

```
cohort
```

```
#> # A tibble: 2 x 4  
#>   cohortDefinitionId subjectId cohortStartDate cohortEndDate  
#>           <dbl>      <dbl> <date>           <date>  
#> 1             1          1 2022-01-01      2022-01-15  
#> 2             2          1 2021-12-15      2022-01-30
```

```
CohortAlgebra::intersectCohorts(  
  connection = connection,  
  sourceCohortDatabaseSchema = cohortDatabaseSchema,  
  sourceCohortTable = tableName,  
  targetCohortDatabaseSchema = cohortDatabaseSchema,  
  targetCohortTable = tableName,  
  cohortIds = c(1, 2, 3),  
  newCohortId = 4  
)
```

```
#> |
```

```
#> Executing SQL took 0.0139 secs
```

```
#> Intersecting cohorts.  
#> Generating eras and saving.
```

Output

```
data
```

```
#> # A tibble: 0 x 4  
#> # ... with 4 variables: cohortDefinitionId <dbl>, subjectId <dbl>, cohortStartDate <date>, cohortEndDate <date>
```

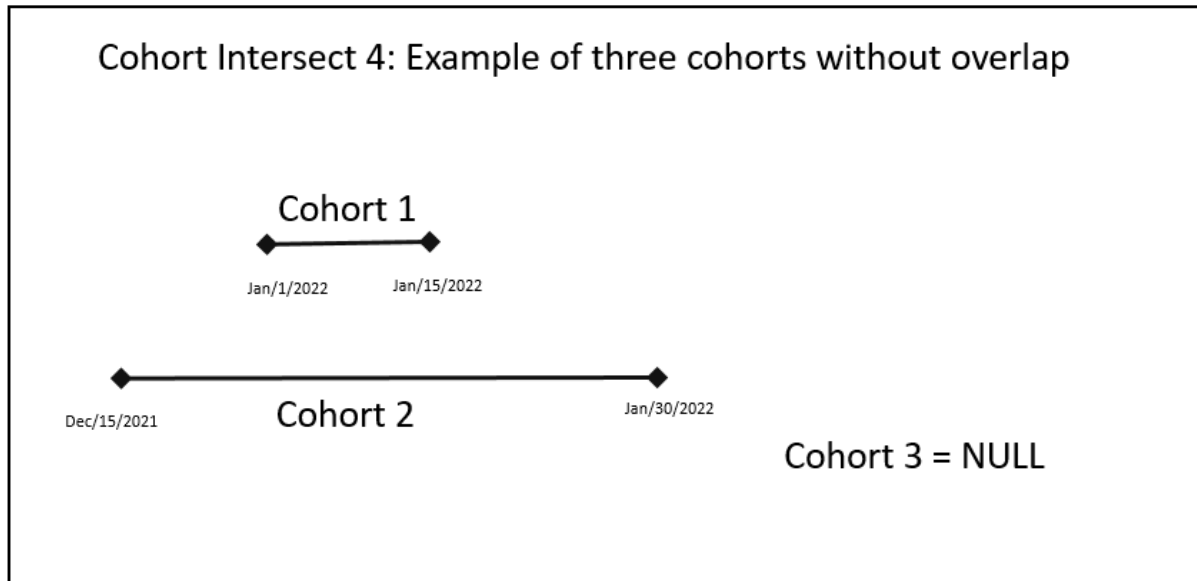
1.3.5 Intersect cohort example 5

Input:

```
cohort
```

```
#> # A tibble: 2 x 4  
#>   cohortDefinitionId subjectId cohortStartDate cohortEndDate  
#>           <dbl>      <dbl> <date>           <date>  
#> 1             1          1 2022-01-01      2022-01-01  
#> 2             2          1 2022-01-01      2022-01-02
```

Input



Output

NULL Cohort – i.e. no cohort is created

Figure 4: Cohort Intersect 4

```
CohortAlgebra::intersectCohorts(
  connection = connection,
  sourceCohortDatabaseSchema = cohortDatabaseSchema,
  sourceCohortTable = tableName,
  targetCohortDatabaseSchema = cohortDatabaseSchema,
  targetCohortTable = tableName,
  cohortIds = c(1, 2),
  newCohortId = 3
)
```

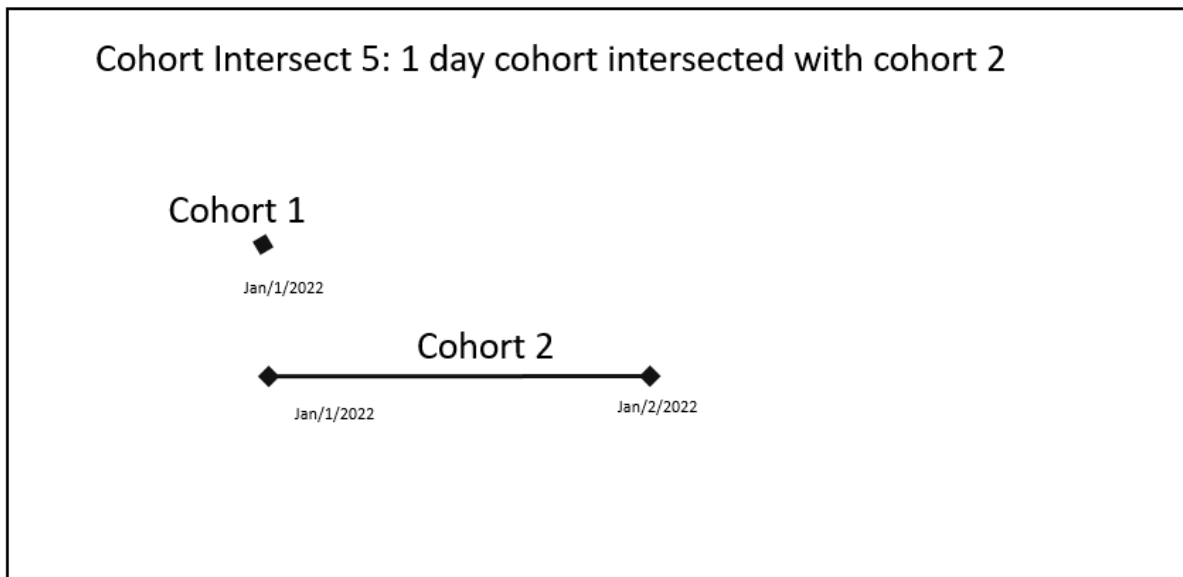
```
#> |
```

```
#> Executing SQL took 0.0132 secs
```

```
#> Intersecting cohorts.
```

```
#> Generating eras and saving.
```

Input



Output



Figure 5: Cohort Intersect 5

Output

```
data
```

```
#> # A tibble: 1 x 4
#>   cohortDefinitionId subjectId cohortStartDate cohortEndDate
#>           <dbl>       <dbl> <date>           <date>
#> 1                 3         1 2022-01-01      2022-01-01
```

1.4 Minus Cohort

Input:

```
cohort
```

```
#> # A tibble: 2 x 4
#>   cohortDefinitionId subjectId cohortStartDate cohortEndDate
#>           <dbl>       <dbl> <date>           <date>
#> 1                 1         1 2022-01-01      2022-03-01
#> 2                 2         1 2022-02-10      2022-05-10
```

```
CohortAlgebra::minusCohorts(
  connection = connection,
  sourceCohortDatabaseSchema = cohortDatabaseSchema,
  sourceCohortTable = tableName,
  targetCohortDatabaseSchema = cohortDatabaseSchema,
  targetCohortTable = tableName,
  firstCohortId = 1,
  secondCohortId = 2,
  newCohortId = 3
)
```

```
#> |
```

```
#> Executing SQL took 0.0161 secs
```

```
#> |
```

```
#> Executing SQL took 0.0245 secs
```

```
#> Performing minus operation.
```

```
#> |
```

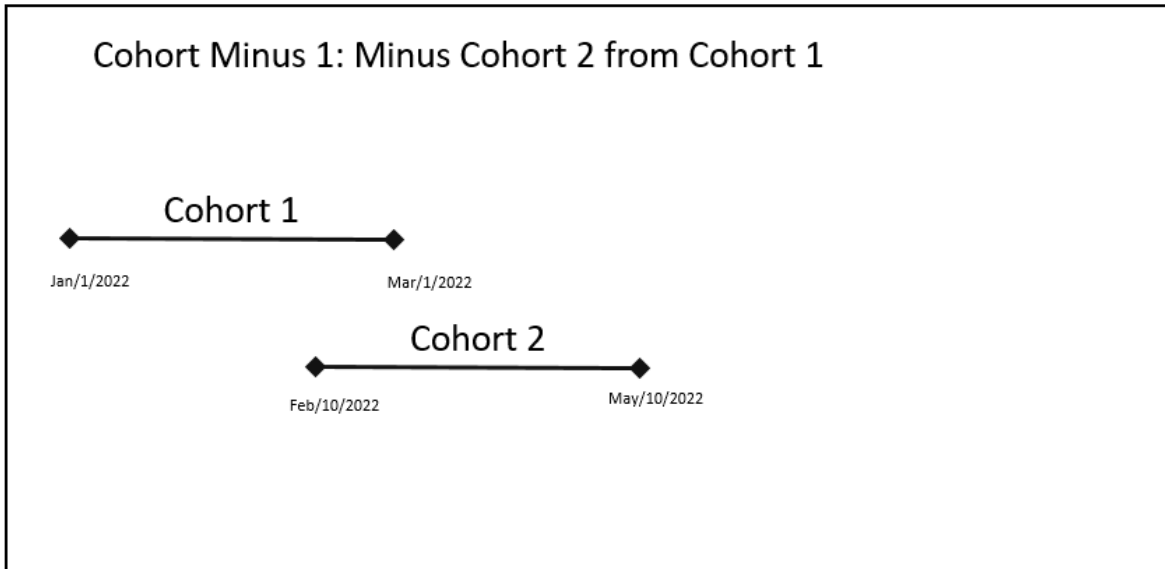
```
#> Executing SQL took 0.0138 secs
```

```
#> Intersecting cohorts.
```

```
#> Generating eras and saving.
```

Output for example 1

Input



Output



Figure 6: Cohort Minus

```
data
```

```
#> # A tibble: 1 x 4
#>   cohortDefinitionId subjectId cohortStartDate cohortEndDate
#>           <dbl>       <dbl> <date>           <date>
#> 1             3         1 2022-01-01      2022-02-09
```

But if the cohorts are switched, i.e. minus cohort 1 from Cohort 2

```
CohortAlgebra::minusCohorts(
  connection = connection,
  sourceCohortDatabaseSchema = cohortDatabaseSchema,
  sourceCohortTable = tableName,
  targetCohortDatabaseSchema = cohortDatabaseSchema,
  targetCohortTable = tableName,
  firstCohortId = 2,
  secondCohortId = 1,
  newCohortId = 4
)
```

```
#> |
```

```
#> Executing SQL took 0.276 secs
```

```
#> |
```

```
#> Executing SQL took 0.217 secs
```

```
#> Performing minus operation.
```

```
#> |
```

```
#> Executing SQL took 0.0259 secs
```

```
#> Intersecting cohorts.
```

```
#> Generating eras and saving.
```

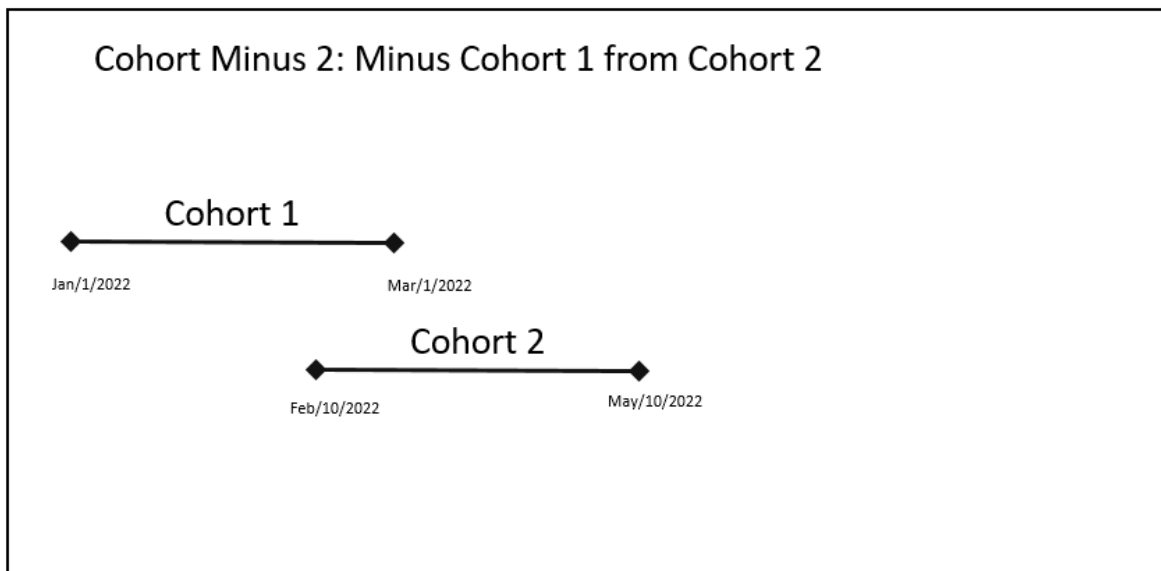
Output

```
data
```

```
#> # A tibble: 1 x 4
#>   cohortDefinitionId subjectId cohortStartDate cohortEndDate
#>           <dbl>       <dbl> <date>           <date>
#> 1             4         1 2022-03-02      2022-05-10
```

Sequence of cohorts are important for minusCohort

Input



Output

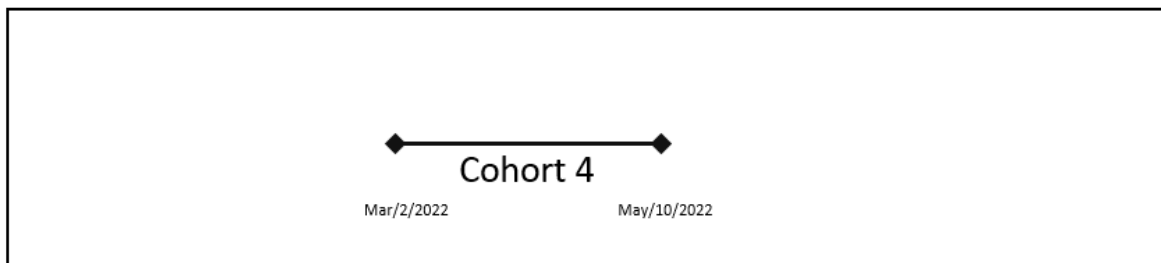


Figure 7: Cohort Minus

1.5 Modify Cohort

Sometimes there is a need to modify a previously instantiated cohorts. Modification may be censoring (left or right) based on calendar date. This may be done using `modifyCohort` as follows:

```
#> Connecting using PostgreSQL driver
```

1.5.1 Example 1: Modify cohort based on calendar date censoring.

Let us say we have a simple cohort as follows:

```
#> # A tibble: 1 x 4
#>   cohortDefinitionId subjectId cohortStartDate cohortEndDate
#>           <dbl>       <dbl> <date>           <date>
#> 1                1         1 1999-01-01      1999-01-31
```

We can censor the dates (left, right, or both). Parameter `cohortStartCensorDate` performs left censor, while `cohortEndCensorDate` performs right censor. This function is useful if you need to force exit based on calendar dates.

```
CohortAlgebra::modifyCohort(
  connection = connection,
  cohortDatabaseSchema = cohortDatabaseSchema,
  cohortTable = tableName,
  oldCohortId = 1,
  newCohortId = 2,
  cohortStartCensorDate = as.Date("1999-01-05"), # for left censor
  cohortEndCensorDate = as.Date("1999-01-25") # for right censor
)
```

Gives the following output

```
#> # A tibble: 1 x 4
#>   cohortDefinitionId subjectId cohortStartDate cohortEndDate
#>           <dbl>       <dbl> <date>           <date>
#> 1                2         1 1999-01-05      1999-01-25
```

1.5.2 Example 2: Modify cohort by filtering cohort records by date range.

We can also filter an instantiated cohort and create a new cohort by filtering the original cohort by date ranges. This may be applied to `cohort_start_date`, `cohort_end_date` or both. Lets take this cohort as an example:

```
#> # A tibble: 2 x 4
#>   cohortDefinitionId subjectId cohortStartDate cohortEndDate
#>           <dbl>       <dbl> <date>           <date>
#> 1                3         3 2010-01-01      2010-01-05
#> 2                3         3 1999-01-15      1999-01-25
```

We can filter by `cohort_start_date` using the parameter `cohortStartFilterRange` as follows:


```
CohortAlgebra::modifyCohort(
  connection = connection,
  cohortDatabaseSchema = cohortDatabaseSchema,
  cohortTable = tableName,
  oldCohortId = 3,
  newCohortId = 2,
  cohortStartFilterRange = c(as.Date("1998-01-01"), as.Date("1999-12-31")),
  purgeConflicts = TRUE
)
```

Gives the following output. Note only records where the cohort_start_date was within the given date range became cohortId 2.

```
#> # A tibble: 1 x 4
#>   cohortDefinitionId subjectId cohortStartDate cohortEndDate
#>   <dbl>         <dbl> <date>           <date>
#> 1             2           3 1999-01-15      1999-01-25
```

1.5.3 Example 3: Pad cohorts by adding/subtracting days from cohort start or end date.

We can add or subtracts days to an instantiated cohort and create a new cohort. Lets take this cohort as an example:

```
#> # A tibble: 1 x 4
#>   cohortDefinitionId subjectId cohortStartDate cohortEndDate
#>   <dbl>         <dbl> <date>           <date>
#> 1             1           1 1999-01-01      1999-01-31
```

We can pad days as follows:

```
CohortAlgebra::modifyCohort(
  connection = connection,
  cohortDatabaseSchema = cohortDatabaseSchema,
  cdmDatabaseSchema = cohortDatabaseSchema,
  cohortTable = tableName,
  oldCohortId = 1,
  newCohortId = 2,
  purgeConflicts = TRUE,
  cohortStartPadDays = -10,
  cohortEndPadDays = 5
)
```

Notes: because padding days may extend cohort period outside the observation_period (which is not allowed), this function will require access to the cdmDatabaseSchema and the observation_period table.

1.6 Remove subjects from Cohort

If you need to remove subjects from one or more cohorts, who are present in one or more of other cohorts - this can be achieved using this function.

```
#> Connecting using PostgreSQL driver
```

lets suppose we have a cohort table with following data:

```
#> # A tibble: 3 x 4
#>   cohortDefinitionId subjectId cohortStartDate cohortEndDate
#>       <dbl>         <dbl> <date>         <date>
#> 1             1           1 1999-01-01    1999-01-31
#> 2             1           2 2010-01-01    2010-01-05
#> 3             3           2 1999-01-15    1999-01-25
```

and we decide to remove from cohort id 1, all subjects in cohort id 3, and create a new cohort with cohort id 6. `removeOverlappingSubjects` can do this. We expect the output cohort 6, to not have any subjects with `subjectId = 2` because `subjectId 2` is present in cohort id 3.

```
CohortAlgebra::removeOverlappingSubjects(
  connection = connection,
  cohortDatabaseSchema = cohortDatabaseSchema,
  cohortId = 1,
  newCohortId = 6,
  cohortsWithSubjectsToRemove = c(3),
  purgeConflicts = FALSE,
  cohortTable = tableName
)
```

```
#> # A tibble: 1 x 4
#>   cohortDefinitionId subjectId cohortStartDate cohortEndDate
#>       <dbl>         <dbl> <date>         <date>
#> 1             6           1 1999-01-01    1999-01-31
```