How to Use CohortAlgebra R Package

Gowtham A. Rao

2023-01-11

Contents

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")
```

```
#> Warning: package 'dplyr' was built under R version 4.2.2
```

```
#>
#> Attaching package: 'dplyr'

#> The following objects are masked from 'package:stats':
#>
#>     filter, lag

#> The following objects are masked from 'package:base':
#>
#>     intersect, setdiff, setequal, union

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

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
```

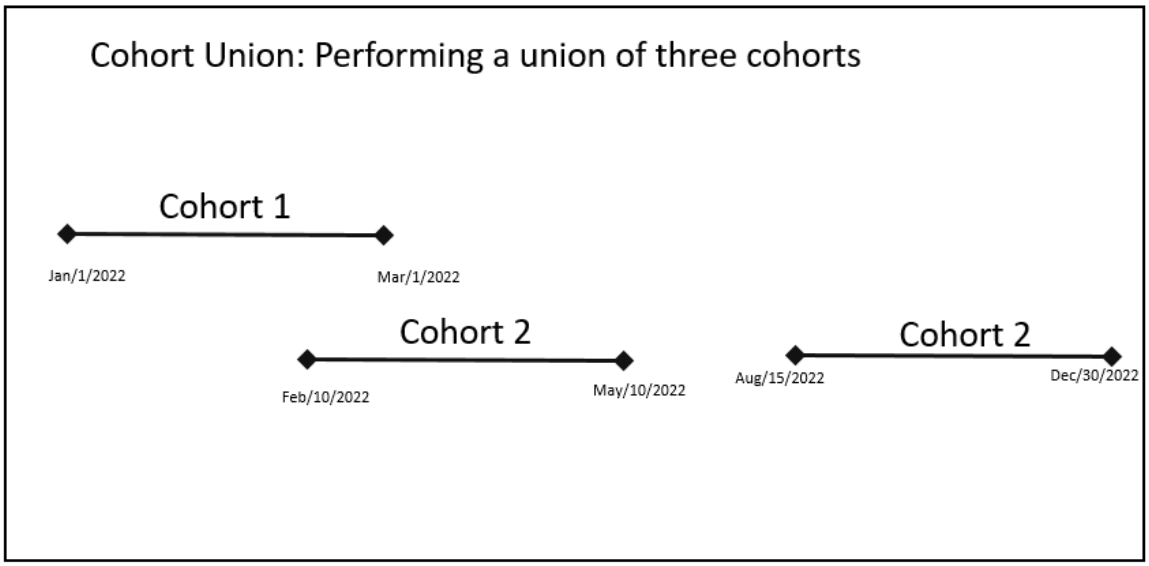
```
#> # A tibble: 3 x 4
#>   cohortDefinitionId subjectId cohortStartDate cohortEndDate
#>                <dbl>     <dbl> <date>          <date>
#> 1                  1         1 2022-01-01      2022-03-01
#> 2                  2         1 2022-02-10      2022-05-10
#> 3                  2         1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

#> Connecting using PostgreSQL driver
```

The union of the two cohorts is expected to give us

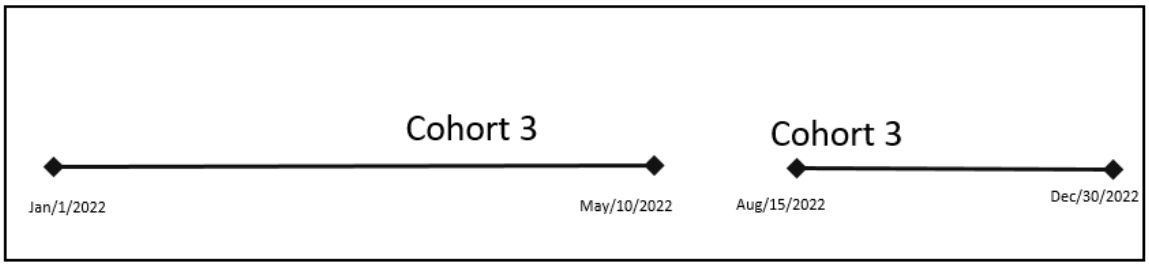
```
cohortExpected
```

```
#> # 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
)
```

```
#>   |
```

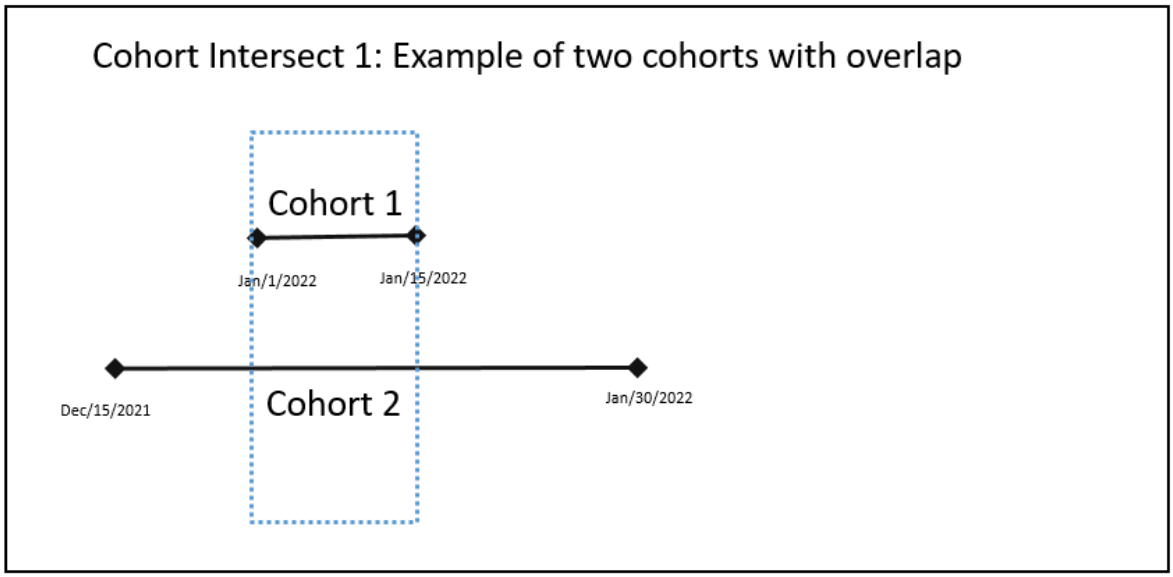
```
#> Executing SQL took 0.0207 secs
#> Currently in a tryCatch or withCallingHandlers block, so unable to add global calling handlers. Paral
```

```
#>  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

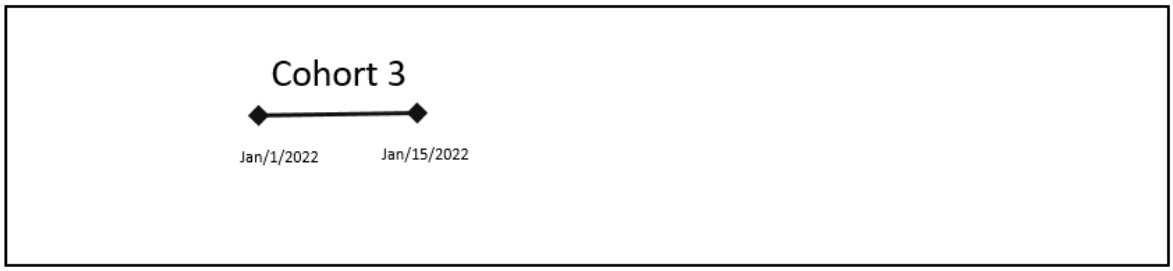


Figure 1: Cohort Intersect 1

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 0.0186 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
```

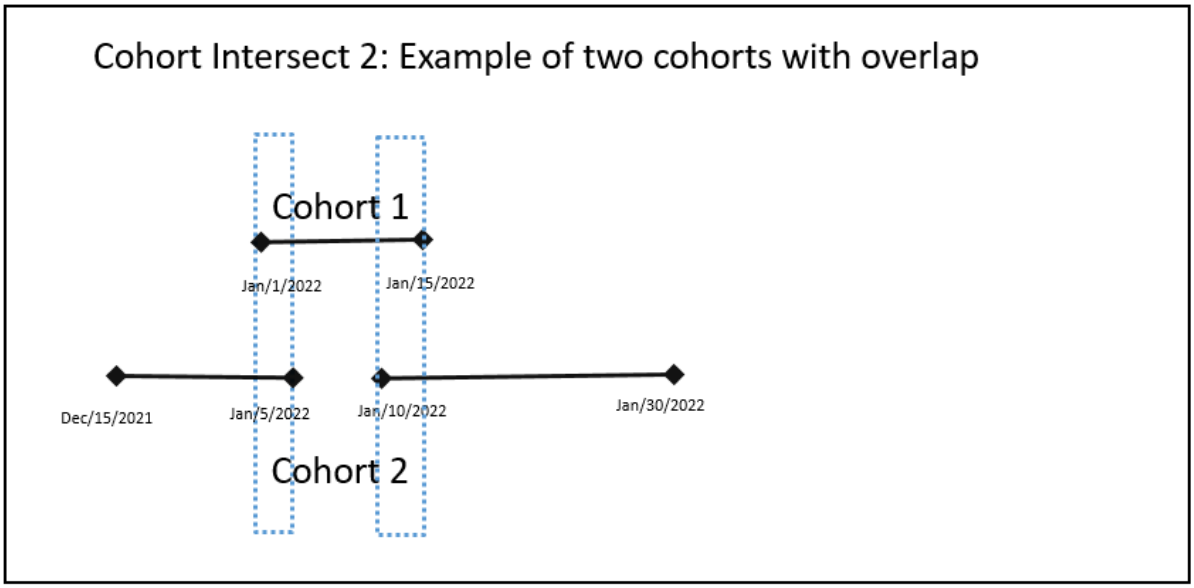
1.3.3 Intersect cohort example 3

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

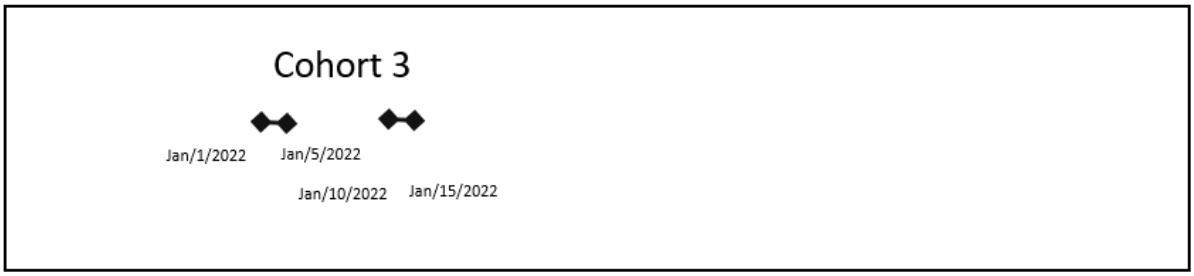


Figure 2: Cohort Intersect 2

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

```
#>   |
```

```
#> Executing SQL took 0.634 secs
```

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

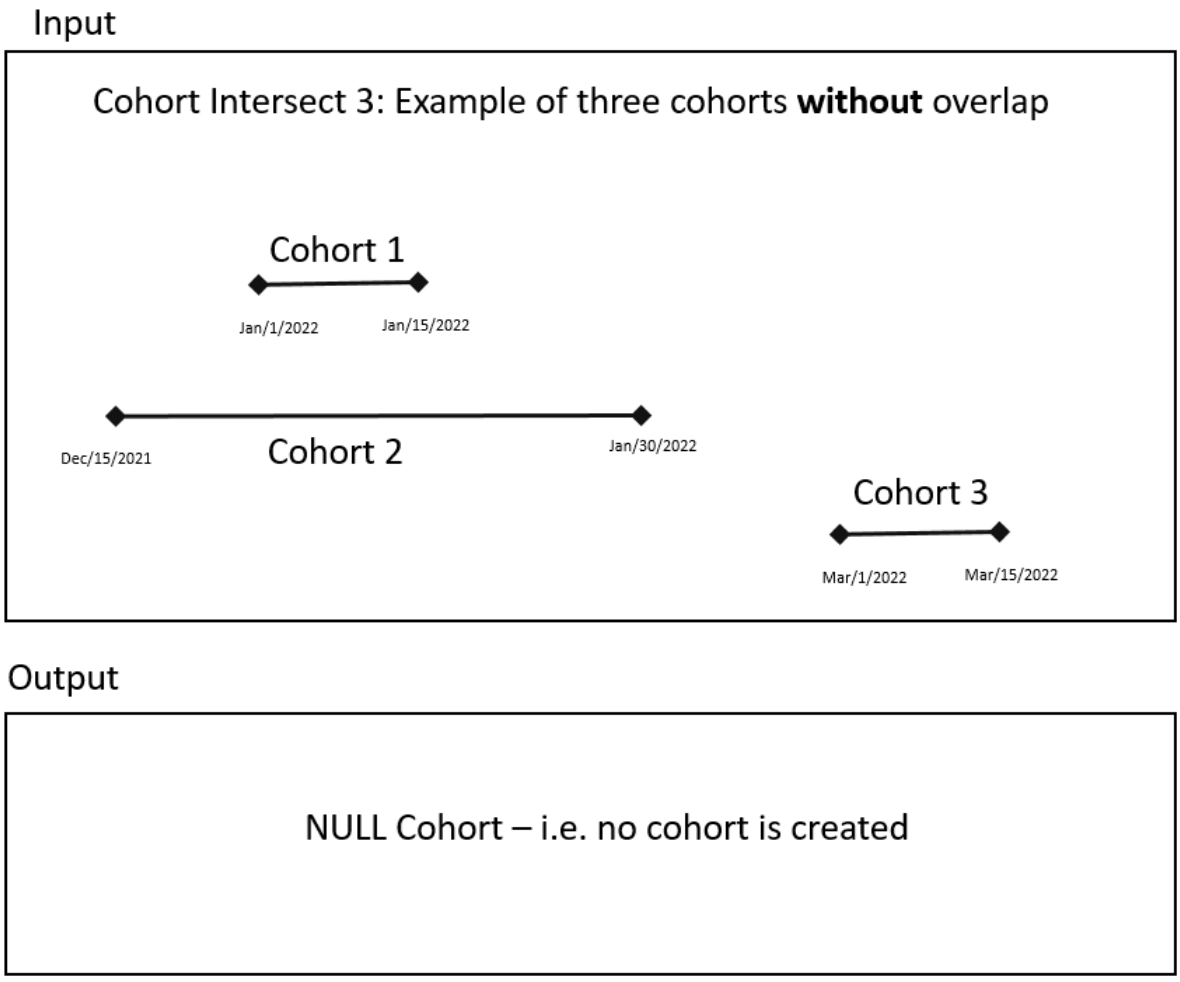


Figure 3: Cohort Intersect 3

Output

```
data
```

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

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 0.244 secs
```

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

Output

```
data
```

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

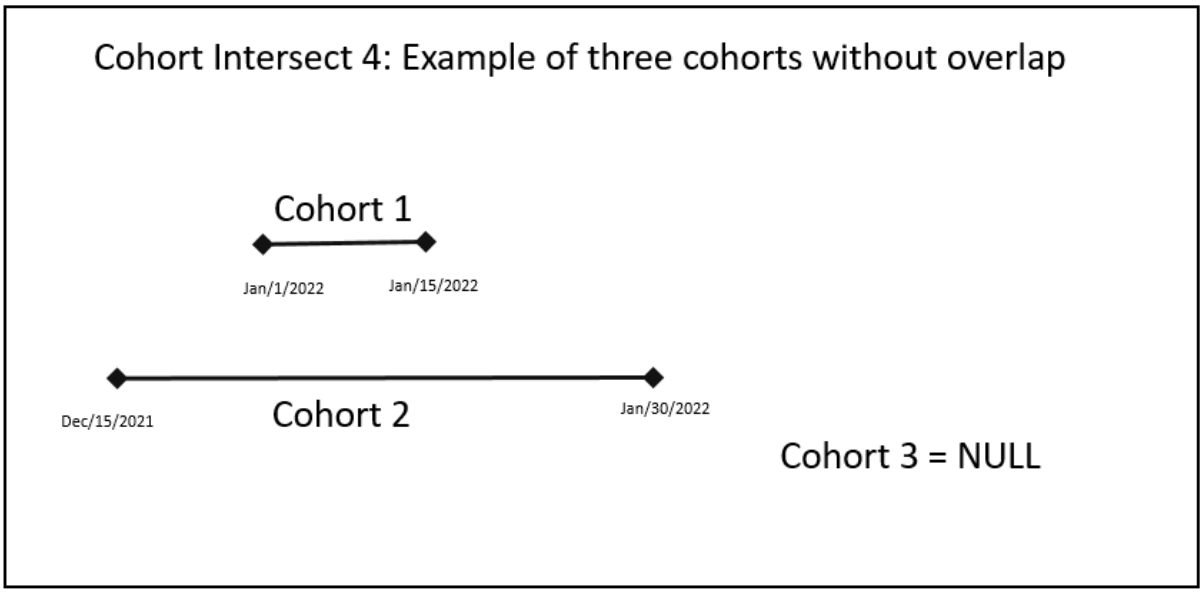
1.3.5 Intersect cohort example 5

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

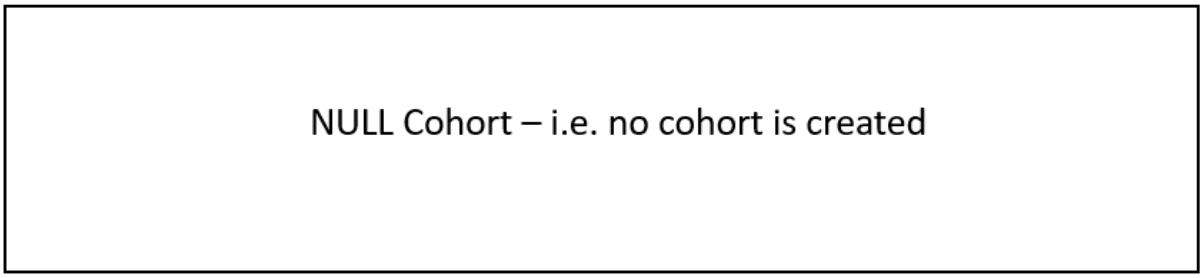


Figure 4: Cohort Intersect 4

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

```
#>   |
```

```
#> Executing SQL took 0.542 secs
```

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

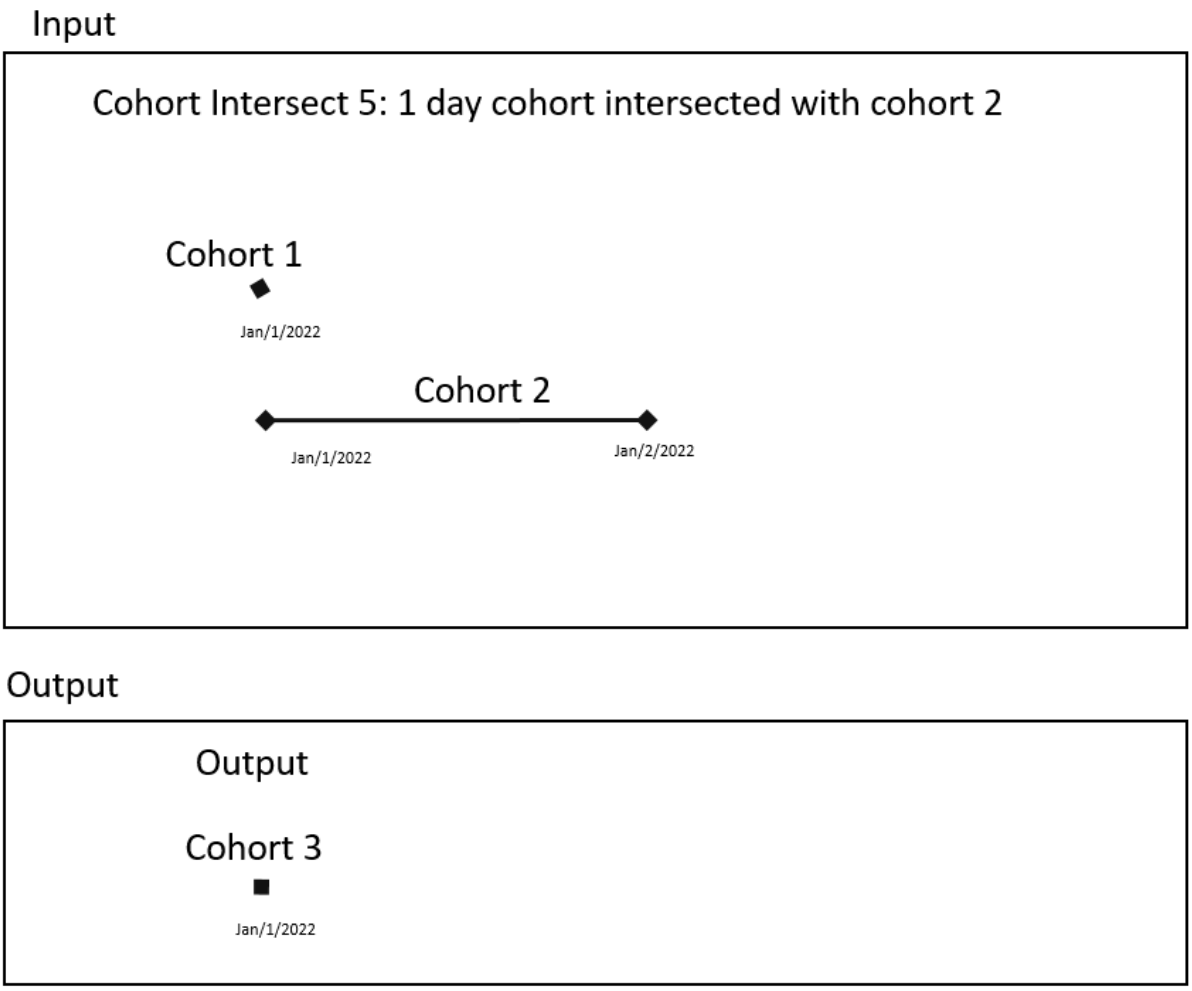


Figure 5: Cohort Intersect 5

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 0.0226 secs
```

```
#>   |
```

```
#> Executing SQL took 0.0228 secs
```

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

```
#> Executing SQL took 0.542 secs
```

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

Output for example 1

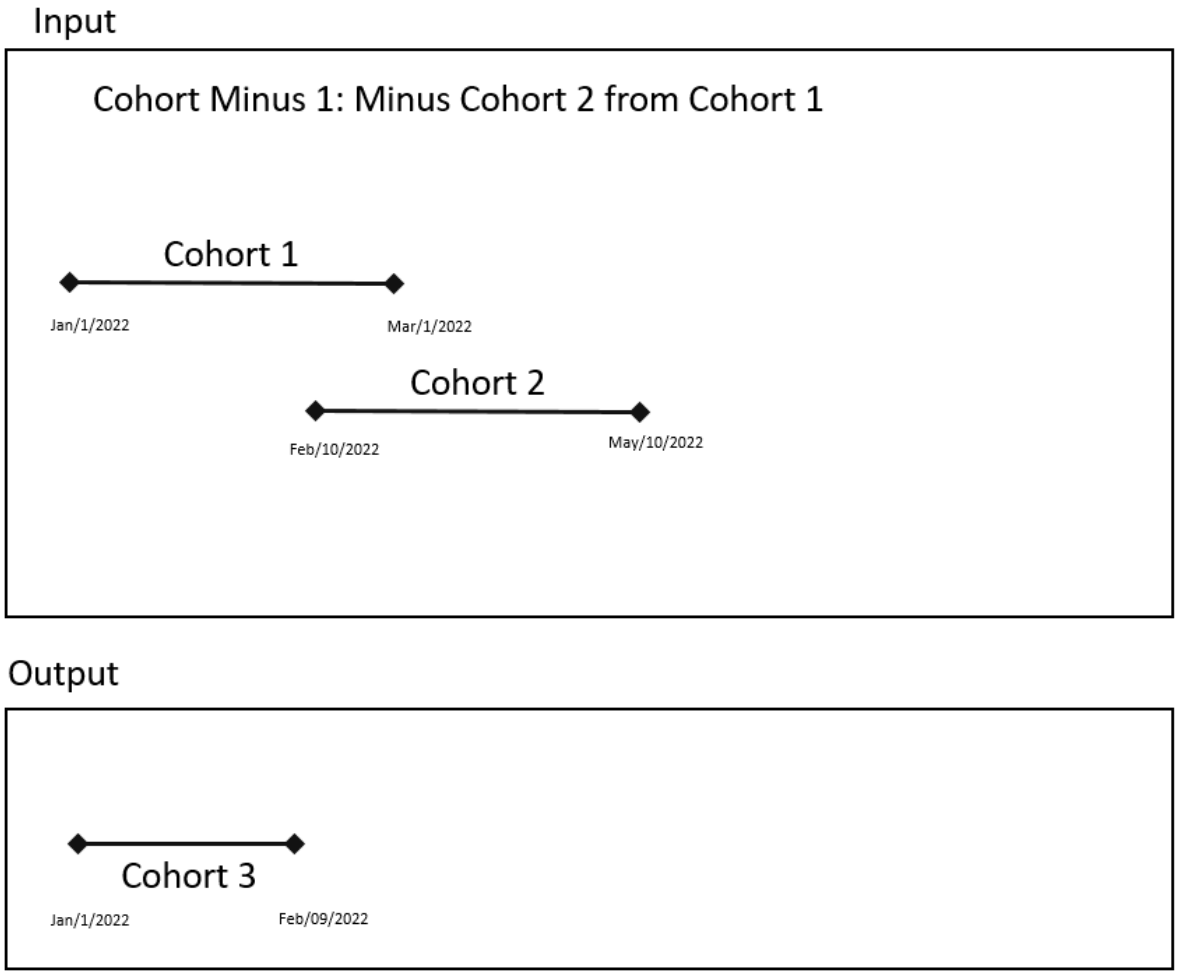


Figure 6: Cohort Minus

```
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 0.0244 secs

#>   |

#> Executing SQL took 0.0172 secs

#> Performing minus operation.
#>   |

#> Executing SQL took 0.0779 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

1.5 Modify Cohort

Sometimes there is a need to modify a previously instantiated cohorts.

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

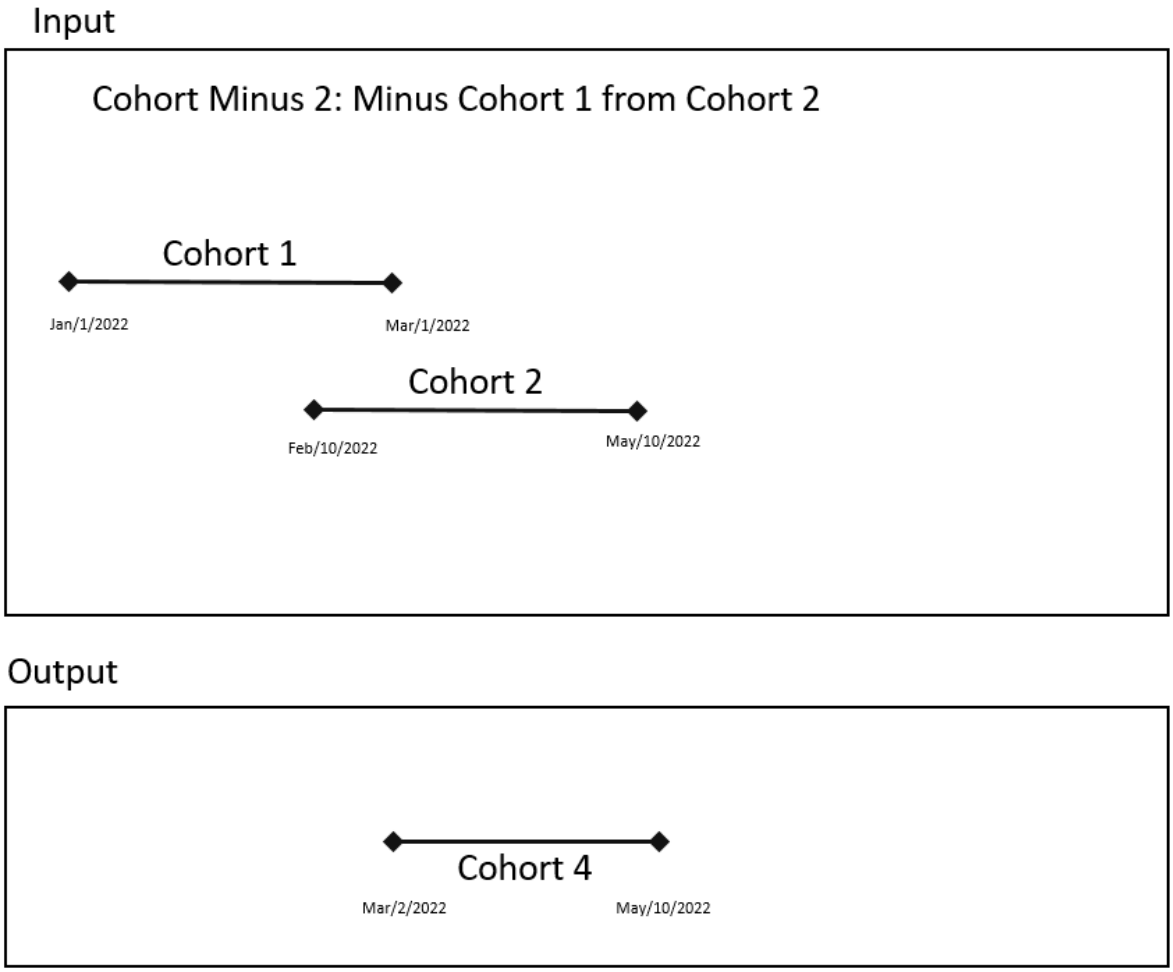


Figure 7: Cohort Minus

1.5.1 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).

```
CohortAlgebra::censorCohortDates(
  connection = connection,
  sourceCohortDatabaseSchema = cohortDatabaseSchema,
  sourceCohortTable = tableName,
  targetCohortDatabaseSchema = cohortDatabaseSchema,
  targetCohortTable = tableName,
  oldCohortId = 1,
  newCohortId = 2,
  cohortStartDateLeftCensor = as.Date("1999-01-05"), # for left censor
  cohortEndDateRightCensor = 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 Change persistence criteria for cohort.

We can change the persistence criteria for a previously instantiated cohort.

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

We can change persistence as follows follows:

```
CohortAlgebra::applyCohortPersistenceCriteria(
  connection = connection,
  sourceCohortDatabaseSchema = cohortDatabaseSchema,
  sourceCohortTable = tableName,
  targetCohortDatabaseSchema = cohortDatabaseSchema,
  targetCohortTable = tableName,
  cdmDatabaseSchema = cohortDatabaseSchema,
  oldCohortId = 1,
  newCohortId = 2,
  purgeConflicts = TRUE,
  offsetCohortStartDate = 30
)
```

A new cohort will be created with cohortId who cohort end date is now different because of change in persistence critera.

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

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
```