

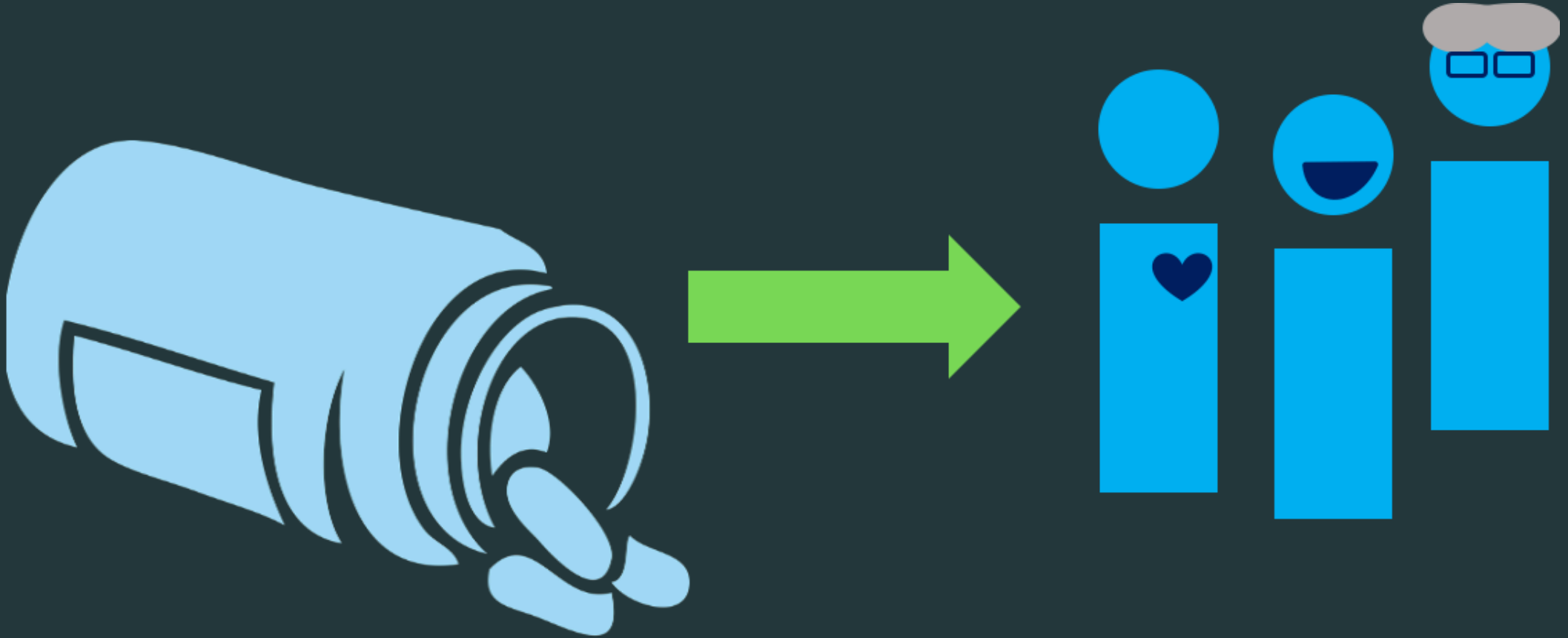
Causal Inference with group_by and summarise

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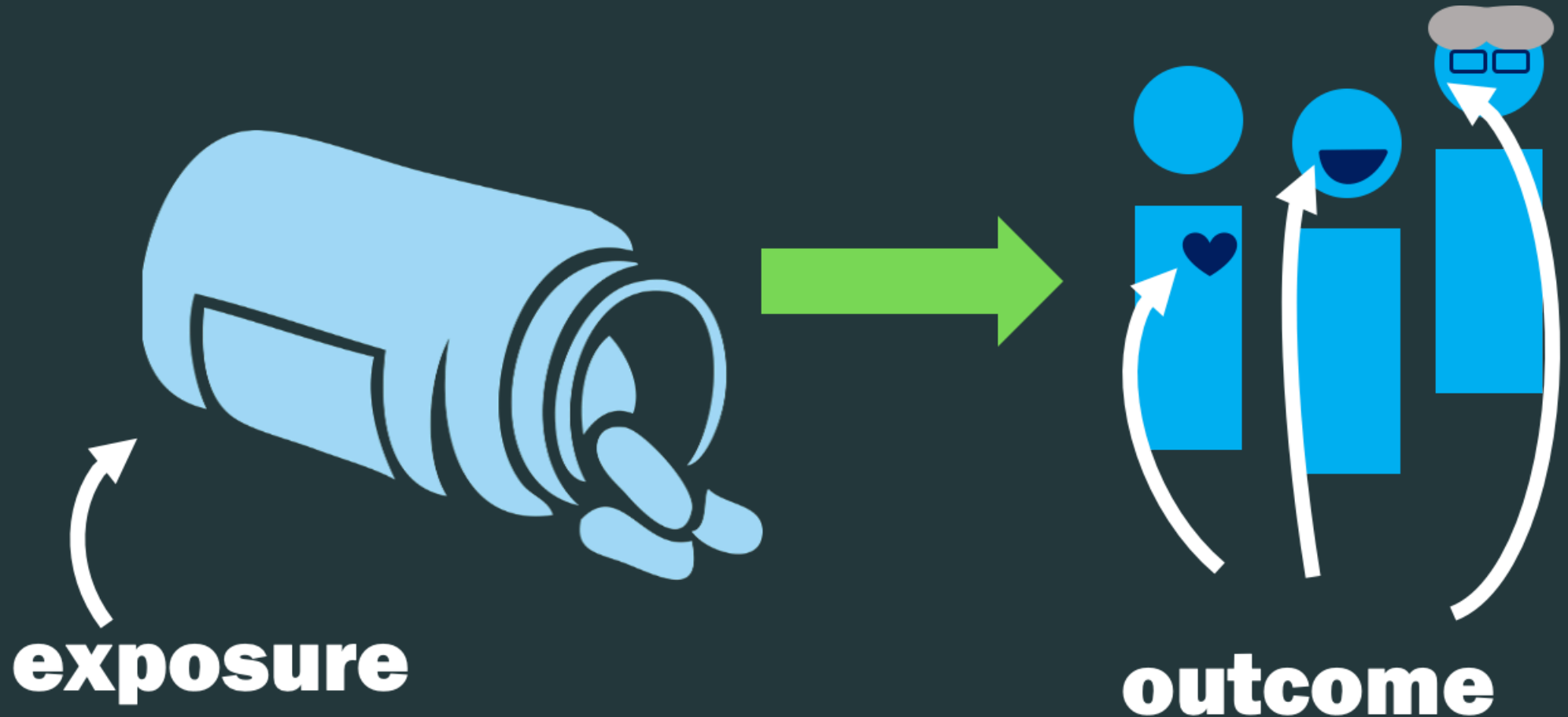
Observational Studies

Goal: To answer a research question



Observational Studies

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Observational Studies

Randomized Controlled Trial



Treatment

Control

Observational Studies

Randomized Controlled Trial



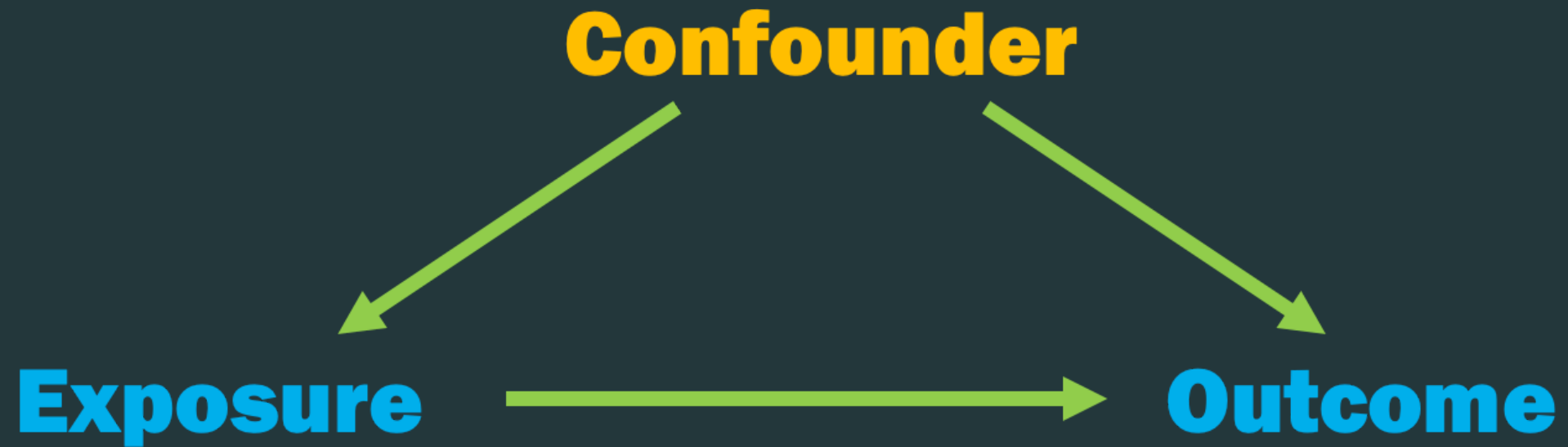
Observational Studies



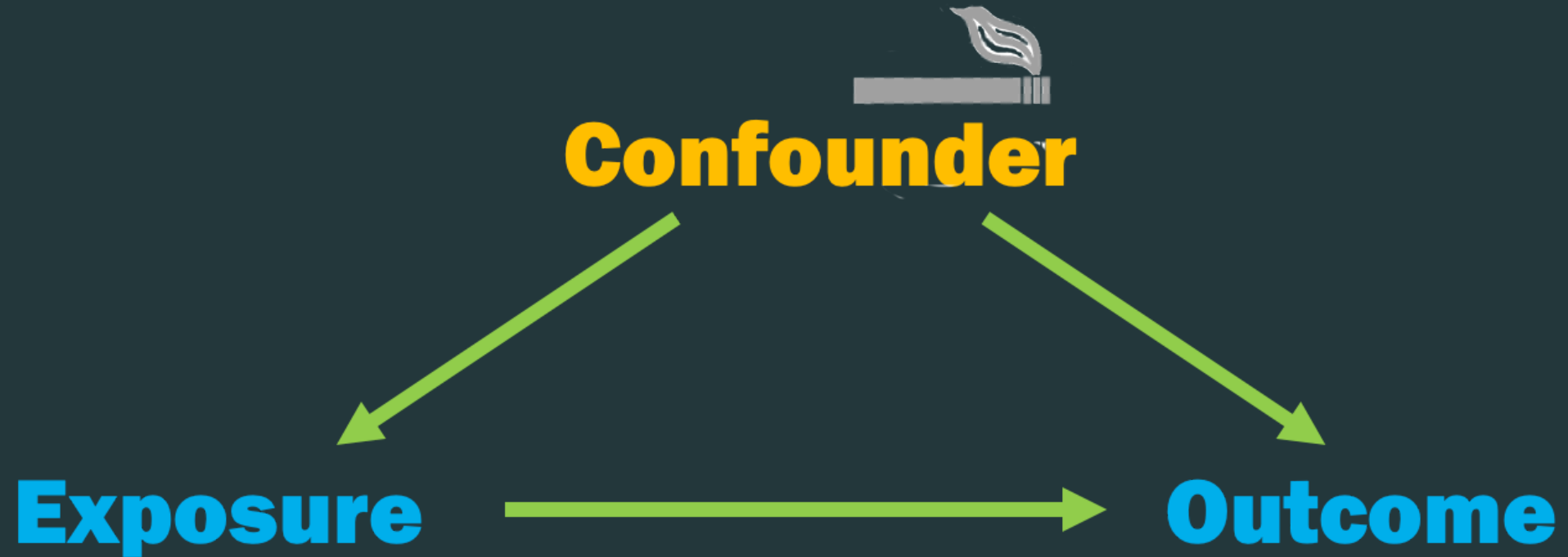




Confounding



Confounding



One binary confounder

Simulation

```
1 n <- 1000
2 sim <- tibble(
3   confounder = rbinom(n, 1, 0.5),
4   p_exposure = case_when(
5     confounder == 1 ~ 0.75,
6     confounder == 0 ~ 0.25
7   ),
8   exposure = rbinom(n, 1, p_exposure),
9   outcome = confounder + rnorm(n)
10 ) |> select(-p_exposure)
11
12 sim
```

Simulation

```
# A tibble: 1,000 × 3
  confounder exposure outcome
  <int>      <int>    <dbl>
1       0         0    1.13
2       0         0    1.11
3       1         1    0.129
4       1         0    1.21
5       0         0    0.0694
6       1         1   -0.663
7       1         1    1.81
8       1         1   -0.912
9       1         0   -0.247
10      0         0    0.998
```

Simulation

```
1 lm(outcome ~ exposure, data = sim)
```

Call:

```
lm(formula = outcome ~ exposure, data = sim)
```

Coefficients:

(Intercept)	exposure
0.2688	0.4070

Simulation

```
1 sim |>  
2   group_by(exposure) |>  
3   summarise(avg_y = mean(outcome))
```

```
# A tibble: 2 × 2  
  exposure avg_y  
    <int> <dbl>  
1         0 0.269  
2         1 0.676
```

Simulation

```
1 sim |>
2   group_by(exposure) |>
3   summarise(avg_y = mean(outcome)) |>
4   pivot_wider(
5     names_from = exposure,
6     values_from = avg_y,
7     names_prefix = "x_"
8   ) |>
9   summarise(estimate = x_1 - x_0)
```

```
# A tibble: 1 × 1
  estimate
  <dbl>
1    0.407
```


Your Turn 1 (**03-ci-with-group-by-and-summarise-exercises.qmd**)

Group the dataset by `confounder` and `exposure`

Calculate the mean of the `outcome` for the groups

Your Turn 1

```
1 sim |>
2   group_by(confounder, exposure) |>
3   summarise(avg_y = mean(outcome))
```

```
# A tibble: 4 × 3
# Groups:   confounder [2]
  confounder exposure  avg_y
    <int>      <int>    <dbl>
1         0         0 -0.00907
2         0         1 -0.0166
3         1         0  1.09
4         1         1  0.936
```

Your Turn 1

```
1 sim |>
2   group_by(confounder, exposure) |>
3   summarise(avg_y = mean(outcome)) |>
4   pivot_wider(
5     names_from = exposure,
6     values_from = avg_y,
7     names_prefix = "x_"
8   ) |>
9   summarise(estimate = x_1 - x_0) |>
10  # note: we would need to weight this
11  # if the confounder groups were not equal sized
12  summarise(estimate = mean(estimate))
```

```
# A tibble: 1 × 1
  estimate
  <dbl>
1 -0.0794
```



Two binary confounders

Simulation

```
1 n <- 1000
2 sim2 <- tibble(
3   confounder_1 = rbinom(n, 1, 0.5),
4   confounder_2 = rbinom(n, 1, 0.5),
5   p_exposure = case_when(
6     confounder_1 == 1 & confounder_2 == 1 ~ 0.75,
7     confounder_1 == 0 & confounder_2 == 1 ~ 0.9,
8     confounder_1 == 1 & confounder_2 == 0 ~ 0.2,
9     confounder_1 == 0 & confounder_2 == 0 ~ 0.1,
10  ),
11  exposure = rbinom(n, 1, p_exposure),
12  outcome = confounder_1 + confounder_2 + rnorm(n)
13 ) |> select(-p_exposure)
14
15 sim2
```

Simulation

```
# A tibble: 1,000 × 4
```

	confounder_1	confounder_2	exposure	outcome
	<int>	<int>	<int>	<dbl>
1	0	0	0	0.521
2	1	0	0	1.38
3	0	0	0	-0.624
4	0	1	1	0.427
5	1	0	1	1.31
6	0	0	0	-0.707
7	1	1	1	2.52
8	1	0	0	1.45
9	0	0	0	-0.505
10	0	1	1	0.793

"

Simulation

```
1 lm(outcome ~ exposure, data = sim2)
```

Call:

```
lm(formula = outcome ~ exposure, data = sim2)
```

Coefficients:

(Intercept)	exposure
0.6395	0.6951

Your Turn 2

Group the dataset by the confounders and exposure

Calculate the mean of the outcome for the groups

Your Turn 2

```
1 sim2 |>
2   group_by(confounder_1, confounder_2, exposure) |>
3   summarise(avg_y = mean(outcome)) |>
4   pivot_wider(
5     names_from = exposure,
6     values_from = avg_y,
7     names_prefix = "x_"
8   ) |>
9   summarise(estimate = x_1 - x_0, .groups = "drop") |>
10  summarise(estimate = mean(estimate))
```

```
# A tibble: 1 × 1
  estimate
  <dbl>
1 -0.0731
```

Simulation

```
1 n <- 100000
2 big_sim2 <- tibble(
3   confounder_1 = rbinom(n, 1, 0.5),
4   confounder_2 = rbinom(n, 1, 0.5),
5   p_exposure = case_when(
6     confounder_1 == 1 & confounder_2 == 1 ~ 0.75,
7     confounder_1 == 0 & confounder_2 == 1 ~ 0.9,
8     confounder_1 == 1 & confounder_2 == 0 ~ 0.2,
9     confounder_1 == 0 & confounder_2 == 0 ~ 0.1,
10  ),
11   exposure = rbinom(n, 1, p_exposure),
12   outcome = confounder_1 + confounder_2 + rnorm(n)
13 ) |> select(-p_exposure)
14
15 big_sim2
```

Simulation

```
# A tibble: 100,000 × 4
```

	confounder_1	confounder_2	exposure	outcome
	<int>	<int>	<int>	<dbl>
1	1	1	1	2.35
2	1	1	0	3.71
3	0	0	0	2.08
4	0	1	1	0.516
5	0	0	0	-0.166
6	1	1	1	1.58
7	0	0	0	0.472
8	1	0	0	3.22
9	0	1	1	0.929
10	0	1	1	1.41

11 . 000 0000

Simulation

```
1 lm(outcome ~ exposure, data = big_sim2)
```

Call:

```
lm(formula = outcome ~ exposure, data = big_sim2)
```

Coefficients:

(Intercept)	exposure
0.6782	0.6561

Simulation

```
1 big_sim2 |>
2   group_by(confounder_1, confounder_2, exposure) |>
3   summarise(avg_y = mean(outcome)) |>
4   pivot_wider(
5     names_from = exposure,
6     values_from = avg_y,
7     names_prefix = "x_"
8   ) |>
9   summarise(estimate = x_1 - x_0, .groups = "drop") |>
10  summarise(estimate = mean(estimate))
```

```
# A tibble: 1 × 1
  estimate
  <dbl>
1    0.0187
```

Continuous confounder?

Simulation

```
1 n <- 10000
2 sim3 <- tibble(
3   confounder = rnorm(n),
4   p_exposure = exp(confounder) / (1 + exp(confounder)),
5   exposure = rbinom(n, 1, p_exposure),
6   outcome = confounder + rnorm(n)
7 ) |> select(-p_exposure)
8
9 sim3
```

Simulation

```
# A tibble: 10,000 × 3
  confounder exposure outcome
    <dbl>      <int>    <dbl>
1   -0.167         0   -0.560
2    0.252         1    0.628
3   -0.321         1   -0.608
4    0.621         0    1.58
5   -0.619         1    0.358
6   -0.897         0   -1.95
7   -2.01         0   -2.50
8    0.296         0   -1.10
9   -0.504         1   -0.316
10  -0.536         1    1.12
```


Simulation

```
1 lm(outcome ~ exposure, data = sim3)
```

Call:

```
lm(formula = outcome ~ exposure, data = sim3)
```

Coefficients:

(Intercept)	exposure
-0.4036	0.8152

Your Turn 3

Use `ntile()` from `dplyr` to calculate a binned version of `confounder` called `confounder_q`. We'll create a variable with 5 bins.

Group the dataset by the binned variable you just created and `exposure`

Calculate the mean of the outcome for the groups

Your Turn 3

```
1 sim3 |>
2   mutate(confounder_q = ntile(confounder, 5)) |>
3   group_by(confounder_q, exposure) |>
4   summarise(avg_y = mean(outcome)) |>
5   pivot_wider(
6     names_from = exposure,
7     values_from = avg_y,
8     names_prefix = "x_"
9   ) |>
10  summarise(estimate = x_1 - x_0) |>
11  summarise(estimate = mean(estimate))
```

```
# A tibble: 1 × 1
  estimate
  <dbl>
1    0.0728
```

What if we could come
up with a **summary**
score of all
confounders?