Host heterogeneity and SARS-CoV-2: from vaccine inequity to variants of concern

Undergraduate Research Symposium (URES)

Ikgyu Shin Tom

Pathogen Dynamics Across Scales (PaDAS) Lab

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

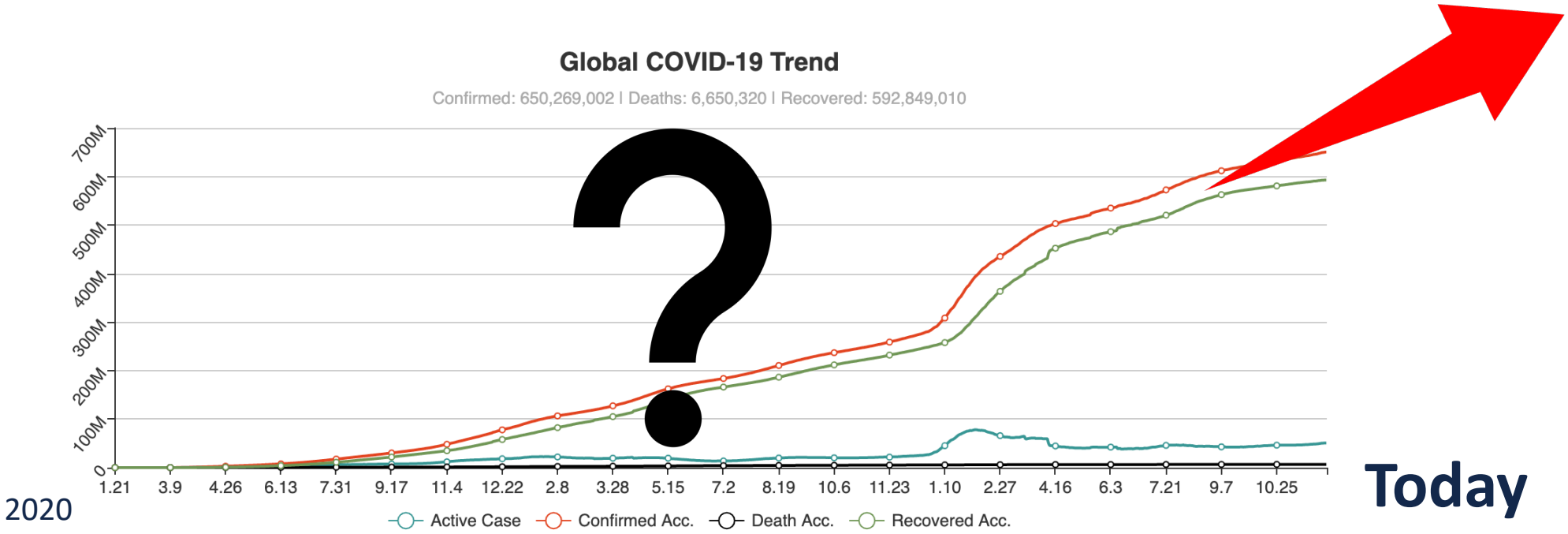
Overview

Sub-national SARS-CoV-2 vaccine uptake inequalities and their consequences for disease transmission

Sophie L. Larsen[1], Ikgyu Shin[2], Rafael Anorga[3†], Jefrin Joseph[4†], Haylee West[4†], Marc Lipsitch[5], Ayesha S. Mahmud[6], and Pamela P. Martinez[2,4*]

[1]*School of Integrative Biology, University of Illinois Urbana-Champaign, Urbana, IL, USA*
[2]*Department of Statistics, University of Illinois Urbana-Champaign, Urbana, IL, USA*
[3]*Division of Epidemiology and Biostatistics, School of Public Health, University of Illinois Chicago, Chicago, IL, USA*
[4]*Department of Microbiology, School of Molecular and Cellular Biology, University of Illinois Urbana-Champaign, Urbana, IL, USA*
[5]*Department of Epidemiology, Harvard T.H. Chan School of Public Health, Boston, MA, USA*
[6]*Department of Demography, University of California, Berkeley, CA, USA*
[†]*These authors contributed equally to this work*

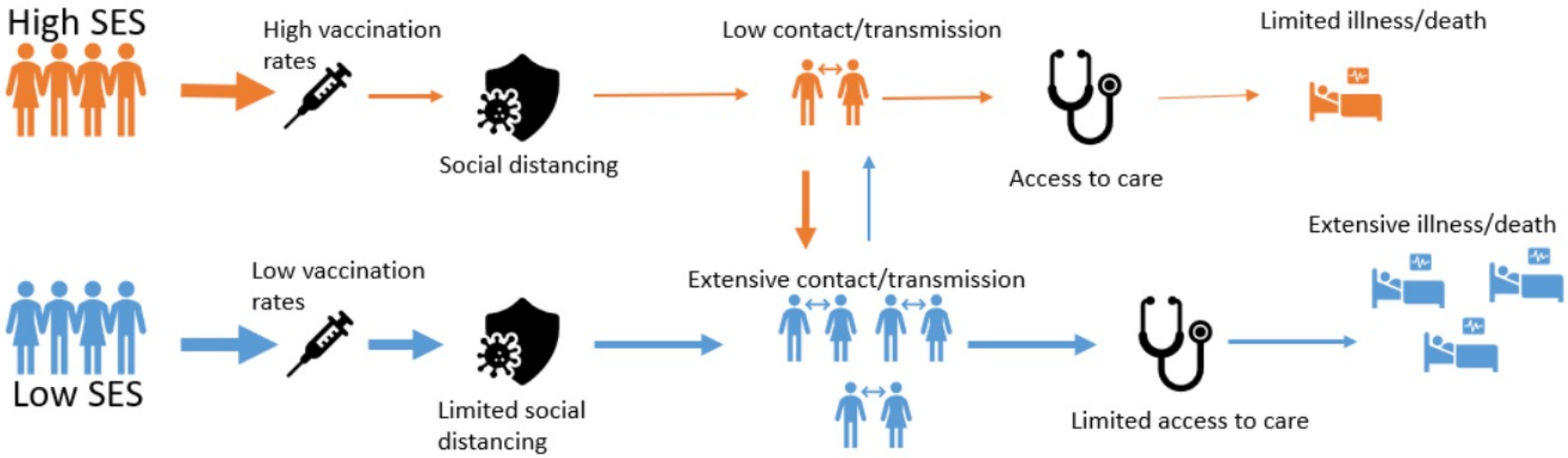
Motivation



2020

Today

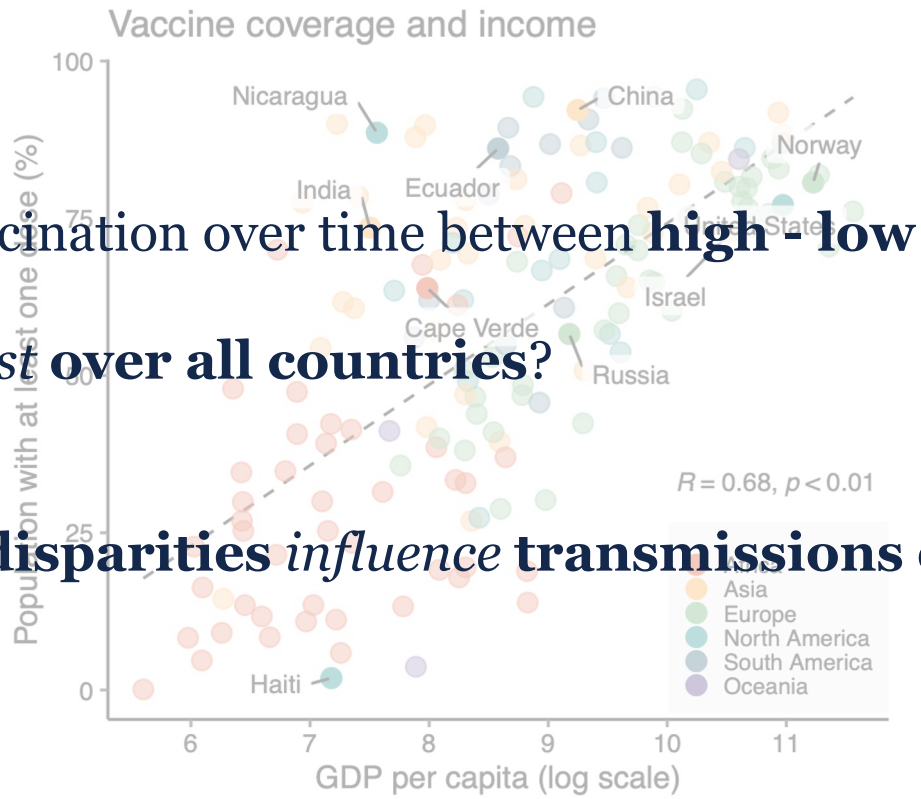
Motivation



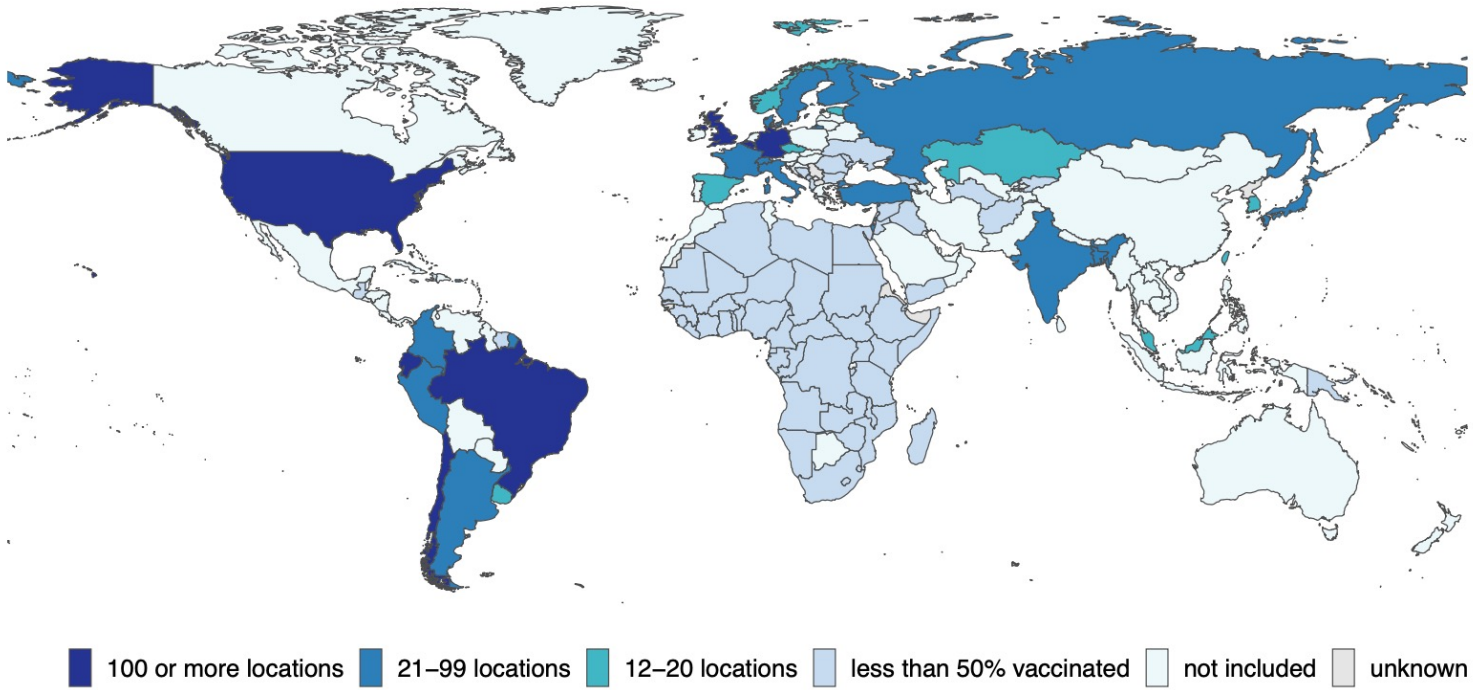
Socioeconomic (**SES**) : relating to or concerned with the interaction of **social** and **economic** factors

Questions

- What are the **trends** of vaccination over time between **high - low SES groups** within countries?
  - Did these **trends** *persist* **over all countries**?
- How do these **trends** and **disparities** *influence* **transmissions** of SARS-CoV-2?



Data Sources



Data Required

country	resolution	location	pop	date	dose	vaccine	vnum	vcum	vperc
Italy	1	Abruzzo	1281012	2021-08-13	3 or booster	Janssen	0	0	0
Italy	1	Abruzzo	1281012	2021-08-05	partial	Janssen	5	0	0
Italy	1	Abruzzo	1281012	2021-08-05	full	Janssen	0	0	0
Italy	1	Abruzzo	1281012	2021-08-13	partial	Janssen	1	0	0
Italy	1	Abruzzo	1281012	2022-03-19	partial	Moderna	0	0	0
Italy	1	Abruzzo	1281012	2021-12-06	3 or booster	Pfizer	543	0	0
Italy	1	Abruzzo	1281012	2021-08-11	3 or booster	Moderna	0	0	0
Italy	1	Abruzzo	1281012	2021-12-12	partial	Moderna	8	0	0
Italy	1	Abruzzo	1281012	2021-06-30	partial	AstraZeneca	12	0	0

Vaccine Data

Italy	income2	gross disposable income
Republic of I	income2	Gross regional income per cap
Spain	income2	Disposable income per capita
UK	income2	GDHI local authority by ITL 1 re
UK	income3	Income - Proportion of LSOAs i
UK	income4	Income deprivation rate
Brazil	income5	POPULAÇÃO EM POBREZA EXT
Kenya	income5	Hardcore poverty (percentage)
Puerto Rico	income5	Median household income (in
Republic of I	income5	household income
United State	income5	MEDHHINC_2019
France	income6	Poverty rate-Total
Kenya	income6	Overall Poverty (percentage)

SES Data

Challenges

Data Aggregation

Varying **Structures**

Incoherent **Notations & Naming**

Too **Large** *to read*

Methods

Data Aggregation

Building **Rubrics**

Understanding **Messages**

Optimizing **Performances**

Varying Structures

	Covid-19, Dose 1, 85 og over, Troms og Finnmark	Covid-19, Dose 1, 85 og over, Trøndelag	Covid-19, Dose 1, 85 og over, Vestfold	Covid-19, Dose 1, 85 og over, Vestland
05.01.2021	33	221	125	237
06.01.2021	283	322	572	649
07.01.2021	87	254	237	382
08.01.2021	105	58	25	60
10.01.2021	0	0	0	0
11.01.2021	0	0	0	0
12.01.2021	10	102	136	301
13.01.2021	151	283	470	408
14.01.2021	73	209	166	371

Building Rubrics

```
for (i in seq_along(df)){
  df[208+i] <- ifelse(grepl("Dose 1,", colnames(df)[i]), "partial",
                      ifelse(grepl("Dose 2,", colnames(df)[i]), "full", "3 or booster"))
  i = i+1
}



i=1
df1 <- county_vaccination

for (i in seq_along(df1)){
  df[416+i] <- ifelse(grepl("Pfizer", colnames(df1)[i]), "Pfizer",
                      ifel

  i = i+1
}


i=1
df2 <- county_vaccination

for (i in seq_along(df2)){
  df[624+i] <- ifelse(grepl("Agder", colnames(df2)[i]), "Agder",
                      ifelse(grepl("oppgitt", colnames(df2)[i]), "Ikke oppgitt",
                             ifelse(grepl("Innlandet", colnames(df2)[i]), "Hedmark and Oppland",
                                    ifelse(grepl("Romsdal", colnames(df2)[i]), "Møre og Romsdal",
                                           ifelse(grepl("Nordland", colnames(df2)[i]), "Nordland",
                                                  ifelse(grepl("Oslo", colnames(df2)[i]), "Oslo (f)",
                                                         ifelse(grepl("Rogaland", colnames(df2)[i]), "Rogaland",
                                                                ifelse(grepl("Svalbard", colnames(df2)[i]), "Svalbard",
                                                                       ifelse(grepl("Finnmark", colnames(df2)[i]), "Troms og Finnmark",
                                                                              ifelse(grepl("Trøndelag", colnames(df2)[i]), "Trøndelag",
                                                                                     ifelse(grepl("Telemark", colnames(df2)[i]), "Vestfold og Telemark",
                                                                                            ifelse(grepl("Vestland", colnames(df2)[i]), "Vestland",
                                                                                                   "Viken")))))))))))
```

```
germ2 <- read_csv("Desktop/research/germany/2022-04-14_Deutschland_Landkreise_COVID-19-Impfungen.csv",
                  col_types = cols(Impfdatum = col_date(format = "%Y-%m-%d"),
                                   Impfschutz = col_character()))%>%
  rename(date = 1, location = 2, age = 3, dose = 4, vnum = 5)%>%
  filter(dose == 2)%>%
  group_by(date, location)%>%
  summarise(vnum = sum(vnum))%>%
  inner_join(pop)%>%
  mutate(dose = "full")
```

Incoherent Notations & Naming

CODGEO	NBMENFISC18	NBPERSMENFISC18	MED18	PIMP18	TP6018	TP60AGE118	TP60AGE218
1	258018	618263	23420	53.6	10.3	14.9	11.8
2	221370	512838	19690	43.6	18.4	29.7	22.8
3	157528	325813	20360	44	15.5	25.3	19.7
4	73620	154535	20580	45.6	16.8	24.9	20.9
5	63474	133391	20880	47.5	13.9	19.9	16.9
6	520415	1099477	22140	55.2	15.8	21.7	17.6

SES Data

Impfdatum	LandkreisId_Impfort	Altersgruppe	Impfschutz	Anzahl
2020-12-27	1003	18-59	1	9
2020-12-27	1003	60	1	19
2020-12-27	1053	18-59	1	13
2020-12-27	1053	60	1	200
2020-12-27	1055	18-59	1	20
2020-12-27	1055	60	1	66
2020-12-27	1056	18-59	1	65
2020-12-27	1056	60	1	7
2020-12-27	1057	18-59	1	12

Vaccine Data

Understanding Messages

CODGEO	NBMENFISC18	NBPERSMENFISC18	MED18	PIMP18	TP6018	TP60AGE118	TP60AGE218
1	258018	618263	23420	53.6	10.3	14.9	11.8
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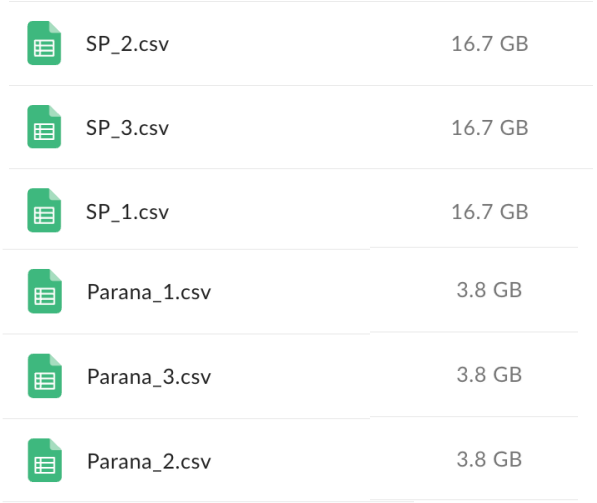
SES Data

name	state	wdId	idIBGE
Abadia de Goiás	GO	Q304652	5200050
Abadia dos Dourados	MG	Q582223	3100104
Abadiânia	GO	Q304716	5200100
Abaeté	MG	Q1615444	3100203
Abaetetuba	PA	Q1615298	1500107
Abaiara	CE	Q1796441	2300101
Abaíra	BA	Q1645077	2900108
Abaré	BA	Q1647789	2900207
Abatiá	PR	Q784855	4100103
Abdon Batista	SC	Q1637414	4200051
Abel Figueiredo	PA	Q942803	1500131

Vaccine Data

Too Large *to read*




```
 user  system elapsed  Method
24.71    0.15   25.42  read.csv (first time)
17.85    0.07   17.98  read.csv (second time)
10.20    0.03   10.32  Optimized read.table
 3.12    0.01    3.22  fread
12.49    0.09   12.69  sqldf
10.21    0.47   10.73  sqldf on SO
10.85    0.10   10.99  ffdf
```

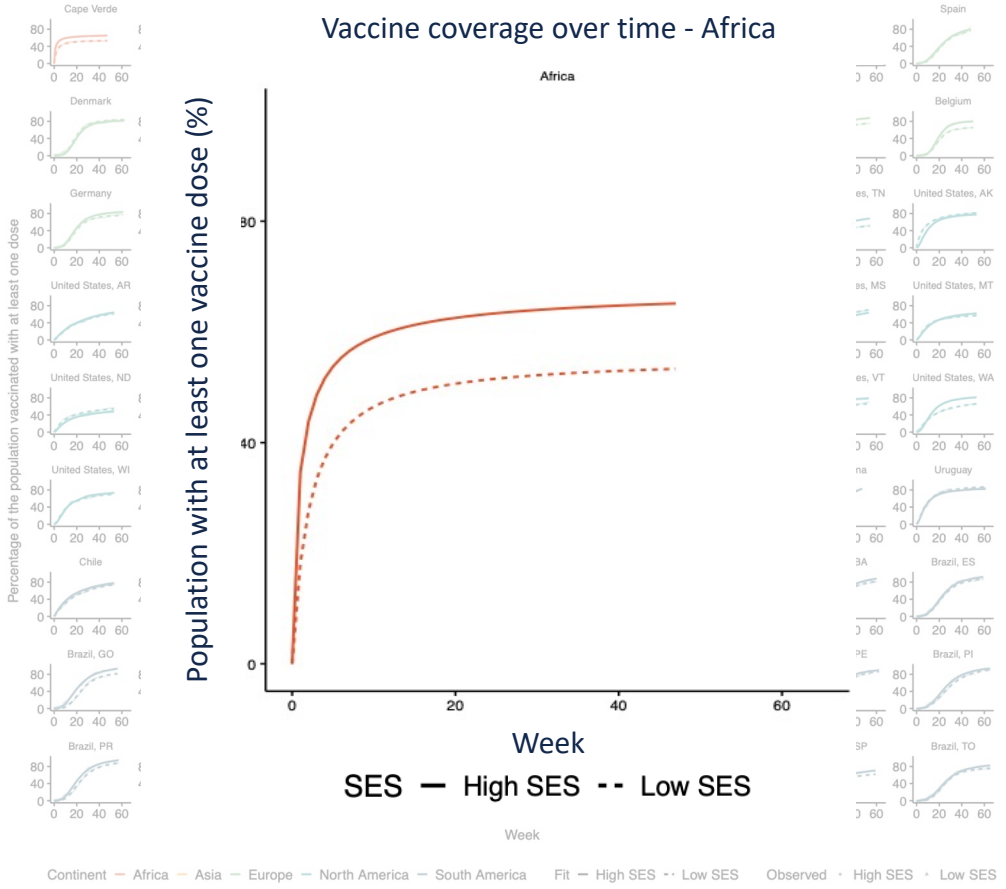
Optimizing Performances

```r
AC_1 <- read_delim("https://uofi.box.com/shared/static/9h2j58jzgqirxdp75azajhqyytlczcim.csv",
                   ";", escape_double = FALSE, col_types = cols(document_id = col_skip(),
                                                                paciente_id = col_skip()), trim_ws = TRUE)%>%
  select(c(24, 26, 27))

AC_2 <- read_delim("https://uofi.box.com/shared/sta[illegible]/y3dy[illegible]v911p23danwn3oqtah1cxp1pq.csv",
                   ";", escape_double = FALSE, col_ty[illegible]cols(document_id = col_skip(),
                                                                paciente_id = col_skip()), trim_ws = TRUE)%>%
  select(c(24, 26, 27))

AC_3 <- read_delim("https://uofi.box.com/shared/static/hdgisfajmntkda6vc31s39rvbx2hodon.csv",
                   ";", escape_double = FALSE, col_types = cols(document_id = col_skip(),
                                                                paciente_id = col_skip()), trim_ws = TRUE)%>%
  select(c(24, 26, 27))
```

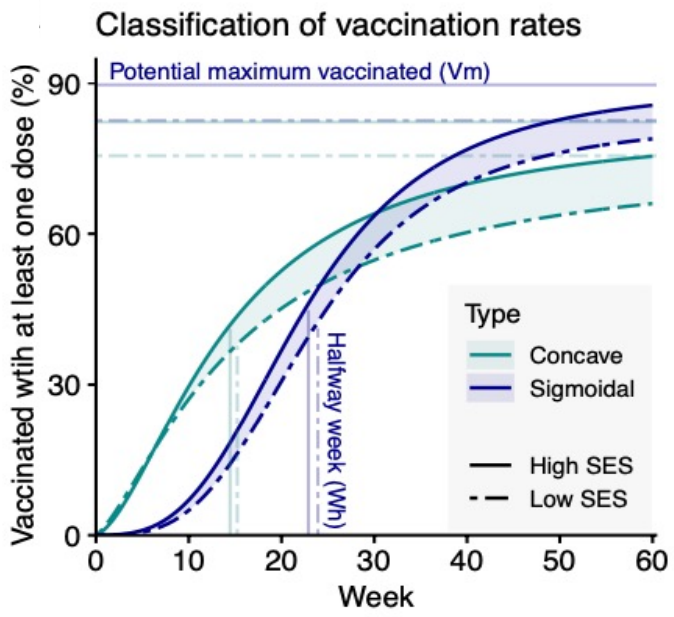
```r
AC_1 <- fread("https://uofi.box.com/shared/static/9h2j58jzgqirxdp75azajhqyytlczcim.csv", select = c(
  "estabelecimento_municipio_codigo", "vacina_fabricante_nome", "vacina_dataAplicacao", "vacina_descricao_dose"
), sep = ";")

AC_2 <- fread("https://uofi.box.com/shared/static/y3dy2xlv911p23danwn3oqtah1cxp1pq.csv", select = c(
  "estabelecimento_municipio_codigo", "vacina_fabricante_nome", "vacina_dataAplicacao", "vacina_descricao_dose"
), sep = ";")

AC_3 <- fread("https://uofi.box.com/shared/static/hdgisfajmntkda6vc31s39rvbx2hodon.csv", select = c(
  "estabelecimento_municipio_codigo", "vacina_fabricante_nome", "vacina_dataAplicacao", "vacina_descricao_dose"
), sep = ";")
```

- BR_Set_1_MG.csv
- BR_Set_1_MS.csv
- BR_Set_1_MT.csv
- BR_Set_1_PA.csv
- BR_Set_1_PB.csv
- BR_Set_1_PE.csv
- BR_Set_1_PI.csv
- BR_Set_1_PR.csv
- BR_Set_1_RJ.csv
- BR_Set_1_RJ1.csv
- BR_Set_1_RJ2.csv
- BR_Set_1_RN.csv
- BR_Set_1_RO.csv
- BR_Set_1_RR.csv
- BR_Set_1_RS.csv
- BR_Set_1_SC.csv
- BR_Set_1_SE.csv
- BR_Set_1_SP.csv
- BR_Set_1_TO.csv

Data Visualization

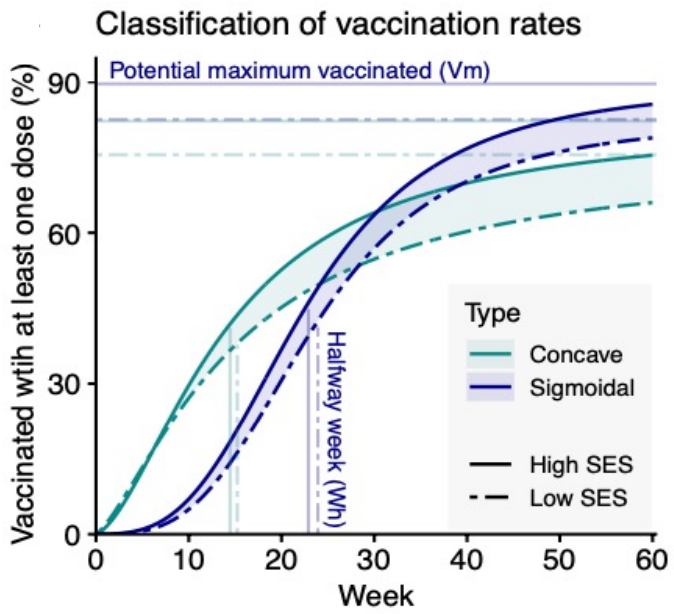


Results



Concave strategy	A rapid initial roll-out Quickly reaching half of the vaccination potential
Sigmoidal strategy	Slow to begin Reaches a steady state more rapidly

Results

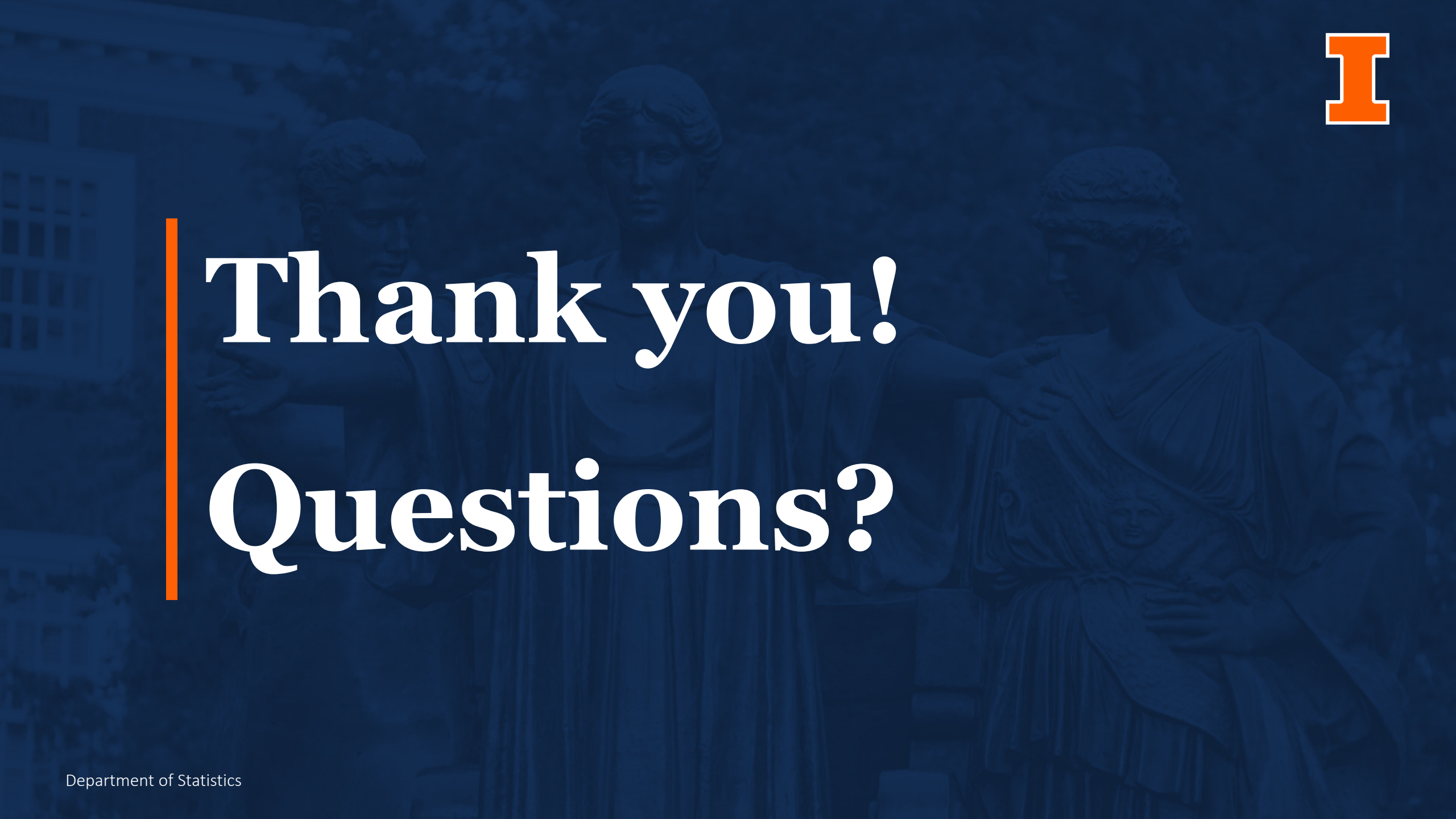


Concave strategy A rapid initial roll-out
Quickly reaching half of the vaccination potential

The **sigmoidal strategy** results in
a **substantially higher burden** of disease

Speed of the initial roll-out > the level of coverage

Modifying the roll-out strategy for **low SES groups** for a reduction in deaths not attainable by modifying the high SES group alone



Thank you!

Questions?