Should vaccination be required

Herd immunity is arithmetic. The mandate is a choice.

This is the one item in the pack with a calculation in it. You will work out how much of a population has to be immune to stop a disease spreading, and then argue about whether the state should require it. Do the arithmetic first. It changes the argument.

75 TO 90 MINUTES | ONE SITTING, OR TWO | WRITTEN WORK AND ONE CALCULATION | VALUE ANNOUNCED WHEN THE PACK OPENS

WHAT THIS ITEM IS WORTH

The point value is announced when the pack opens, printed on the portal beside the item and written on the board. It is not printed here, because the value is set once and printing it in two places is how two different numbers end up in circulation.

What is fixed now is the **size**. This page tells you how long the work takes and what you have to produce. Read that first and decide whether you have the time before you start.

What you are doing

You will calculate the herd immunity threshold for three diseases, explain why protecting people who cannot be vaccinated depends on the people who can, and then take and defend a position on requiring vaccination for school attendance.

WHAT THIS ITEM COSTS YOU

HOW LONG	SITTINGS	WHAT YOU NEED FIRST	WHAT YOU HAND IN
75 to 90 min	One or two	This handout, a calculator, and a device that opens the CDC vaccine page.	A completed threshold table with your working shown, plus one written position of roughly a page.

The science you need first

TWO LAYERS OF IMMUNITY, AND WHERE A VACCINE ACTS

- **Innate immunity** is fast and non-specific. Skin and mucus as barriers, then phagocytes and inflammation. It does not improve with exposure.
- **Adaptive immunity** is slower and specific. B cells produce antibodies against a particular antigen, T cells kill infected cells and coordinate the response, and both leave memory cells behind so the second exposure is answered far faster.
- **A vaccine works on the adaptive layer.** It presents the antigen without the disease, so the memory exists before the real exposure ever happens. That is the whole mechanism.

HERD IMMUNITY, AND THE ARITHMETIC UNDER IT

R0 is the basic reproduction number: the average number of new cases one infected person causes in a population where nobody is immune. If R0 is above 1 the outbreak grows.

Immunity in the population removes some of those onward cases. The share that has to be immune before each case produces less than one new case is the **herd immunity threshold**:

Threshold = 1 minus (1 divided by R0)

Written as a percentage. So at R0 of 4, the threshold is 1 minus 0.25, which is 0.75, or 75 percent immune.

R0 is an estimate, not a constant. It changes with crowding, contact patterns and setting, which is why published values come as ranges. Use the values in the table and note in your write-up that they are estimates.

Read this before you decide

CDC: Vaccine Basics. cdc.gov/vaccines/basics/index.html. Read it for how a vaccine produces immunity and why coverage across a population matters rather than only individual protection.

Part A. Do the arithmetic

Fill in the table. Show the division, not only the answer. Use the middle of each range, and say in the last column what the number means for a school of 400 students.

HERD IMMUNITY THRESHOLD

DISEASE	COMMONLY CITED R0 RANGE	R0 YOU USED	1 DIVIDED BY R0	THRESHOLD AS A PERCENTAGE	STUDENTS IN A SCHOOL OF 400 WHO MUST BE IMMUNE
Measles	12 to 18				
Whooping cough (pertussis)	5 to 17				
Seasonal influenza	1 to 2				

WHAT TO NOTICE WHEN THE TABLE IS FULL

The three thresholds are not close together. Write two sentences on what that means: why a disease with a high R0 leaves almost no room for unvaccinated people, and why a disease with an R0 near 1 behaves completely differently. This is the part of the arithmetic that does work in the argument later, so do not skip it.

Part B. Who the threshold is actually protecting

Some people cannot be vaccinated. Infants below the age for a given vaccine. People receiving chemotherapy or other treatment that suppresses the immune system. People with a documented severe allergic reaction to a vaccine component. None of those people chose it, and none of them can protect themselves by their own decision.

Write three sentences explaining, using your measles number, why the protection of that group depends entirely on the coverage rate among people who can be vaccinated.

Part C. Take a position

1. **Write the strongest version of both sides.** One paragraph arguing that schools should require vaccination for attendance, one arguing they should not. Write both before you choose. If one of them is obviously weaker, you have not written it fairly yet.

   Done when: Both paragraphs would be recognised as fair by someone who holds that view.

2. **State your claim.** One sentence. Should vaccination be required for school attendance, and under what conditions if any.

   Done when: Your claim is a position, not a summary of the debate.

3. **Give one scientific reason.** It must use your threshold number. A reason that would read the same whatever the arithmetic said is not a scientific reason.

   Done when: Your reason names a specific percentage from your own table.

4. **Give one ethical reason.** Name the two things in tension. Usually that is individual autonomy against protection of people who cannot protect themselves, but say it in your own terms.

   Done when: You can name both sides of the tension, not just the one you favour.

5. **Answer the best objection.** Write the strongest argument against your position and answer it in two or three sentences.

   Done when: The objection is one you had to think about.

6. **Name the tradeoff.** One sentence: who is worse off under your position, and how.

   Done when: A specific group is named.

WHAT THE SCIENTIFIC REASON LOOKS LIKE WHEN IT IS DOING REAL WORK

Both sentences argue the same side. Only one of them would read differently if the number were different, and that is the test.

> **Weak, because the arithmetic changes nothing:** Vaccines protect the community, so requiring them is reasonable.
>
> **Strong, because it depends on the number:** At a measles threshold of about 92 percent, a school of 400 can carry roughly 32 non-immune students before transmission is no longer contained. Medical exemptions alone can approach that figure, which is why ...

Where people get stuck

My percentages look too high to be real.

Measles genuinely lands above 90 percent, and that is not a mistake in your arithmetic. It is why measles returns quickly wherever coverage slips. Check your division, then trust it.

I do not know which R0 to use from the range.

Use the middle of the range and write down which value you used. Then add one sentence on what happens to your threshold if you use the bottom of the range instead. Handling an estimate honestly is part of the work.

I have strong feelings about this one.

Good, and it is still not a substitute for the argument. Write the other side first and write it properly. A position that has survived the strongest opposing case is worth far more than one that has never met it.

Is there a right answer here?

Not on the ethics. There is a right answer on the arithmetic, and getting the arithmetic wrong will sink whichever side you argue.

Words this item uses

Antigen

The molecule the immune system recognises as foreign. A vaccine delivers one without the disease.

Antibody

A Y-shaped protein made by B cells that binds one specific antigen to neutralise or tag it.

Lymphocyte

The white blood cell family of adaptive immunity. B cells make antibodies, T cells kill infected cells and coordinate.

Innate immunity

The fast, non-specific first layer: barriers, phagocytes, inflammation.

Adaptive immunity

The specific, slower layer that remembers. Vaccines act here.

R0

Basic reproduction number. Average new cases per case in a fully susceptible population. Above 1 and it grows.

Herd immunity threshold

The share of a population that must be immune before each case causes less than one new case. Calculated as 1 minus 1 over R0.

Medical exemption

A documented reason a person cannot be vaccinated, such as immunosuppression or a severe allergy to a component.

How to submit

- **Where it goes.** The same place as everything else. Your class form on the portal, or handed to Mr. Mendoza in person. Extra credit does not need a different route.
- **What to hand in.** Your written pages. Photographs of handwritten pages are fine. A photograph you cannot read is not.
- **Put your name and period on every page and in every photograph filename.** Unlabelled work cannot be credited, and it is the most common way points get lost.
- **When.** Any day after the pack opens, up to the last week of the semester. There is no deadline inside that window and no penalty for going slowly.
- **Feedback.** You get it back with a note. If a piece is short of full credit you may fix the named thing and resubmit once.