Bicycle Helmet Laws vs. Safety In Numbers

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Philosophical teaser

How long does it take to get somewhere? . . . by bike?

Transportation policy → *intrinsic good?*

Objective	Correlate	Mechanisms	Technology
Wellbeing ←	(Healthy) life expectancy ←	**Active lifestyle** **Mobility safety** **Clean air** Mobility equity Cognitive development Reduced parental burdens Pleasant "third space" Economic efficiency Low resource use Stable climate ⋮	← 

We take life expectancy as a proxy for more sophisticated (and intangible) QALY / DALY / LEGPH / etc. We focus on the first three (boldfaced) mechanisms—the remaining ones should make interesting future work.

Safety through helmets? Safety through popularity?

Safety-In-Numbers: When cycling doubles, risk goes down by

$$1 - 2^{\beta-1} \qquad \beta \approx 0.25 \ldots 0.4$$

e.g. twice as many cyclists → risk decreases by ∼ 34–40%

Weeks: Drivers learn to expect bicycles.

Years: Road infrastructure: safety, convenience, pleasantness.

Decades: Urban design adjusts to new mobility preferences.

Bikeshare systems lower the barriers to bicycling for new or occasional riders, potentially leading to a rapid increase in ridership.

Helmets:

Reduce deaths: In a serious crash or collision with a motor vehicle, bicycle helmets *might* reduce the risk of certain kinds of injury. Let's just assume they're perfect!

Reduce number of cyclists: Helmet requirements cause some fraction of people not to bike.

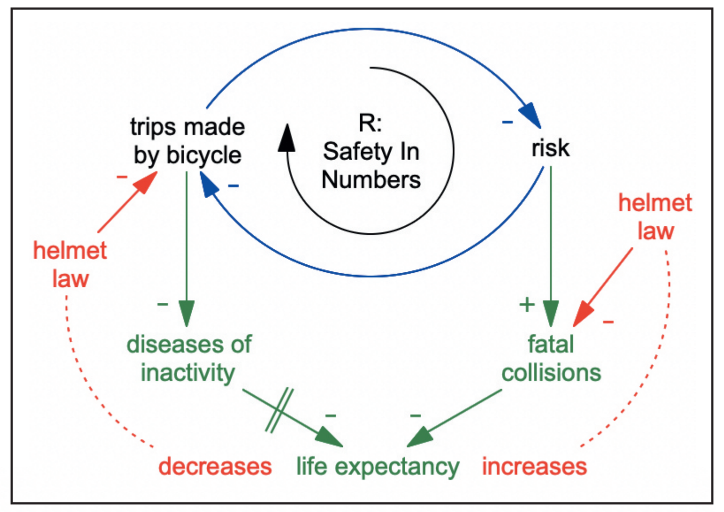
- inconvenience, discomfort, money, ideology, helmet-hair. . .
- Personal bikes: ∼10–40% reduction
- Bikeshare trips: ∼80–90% reduction

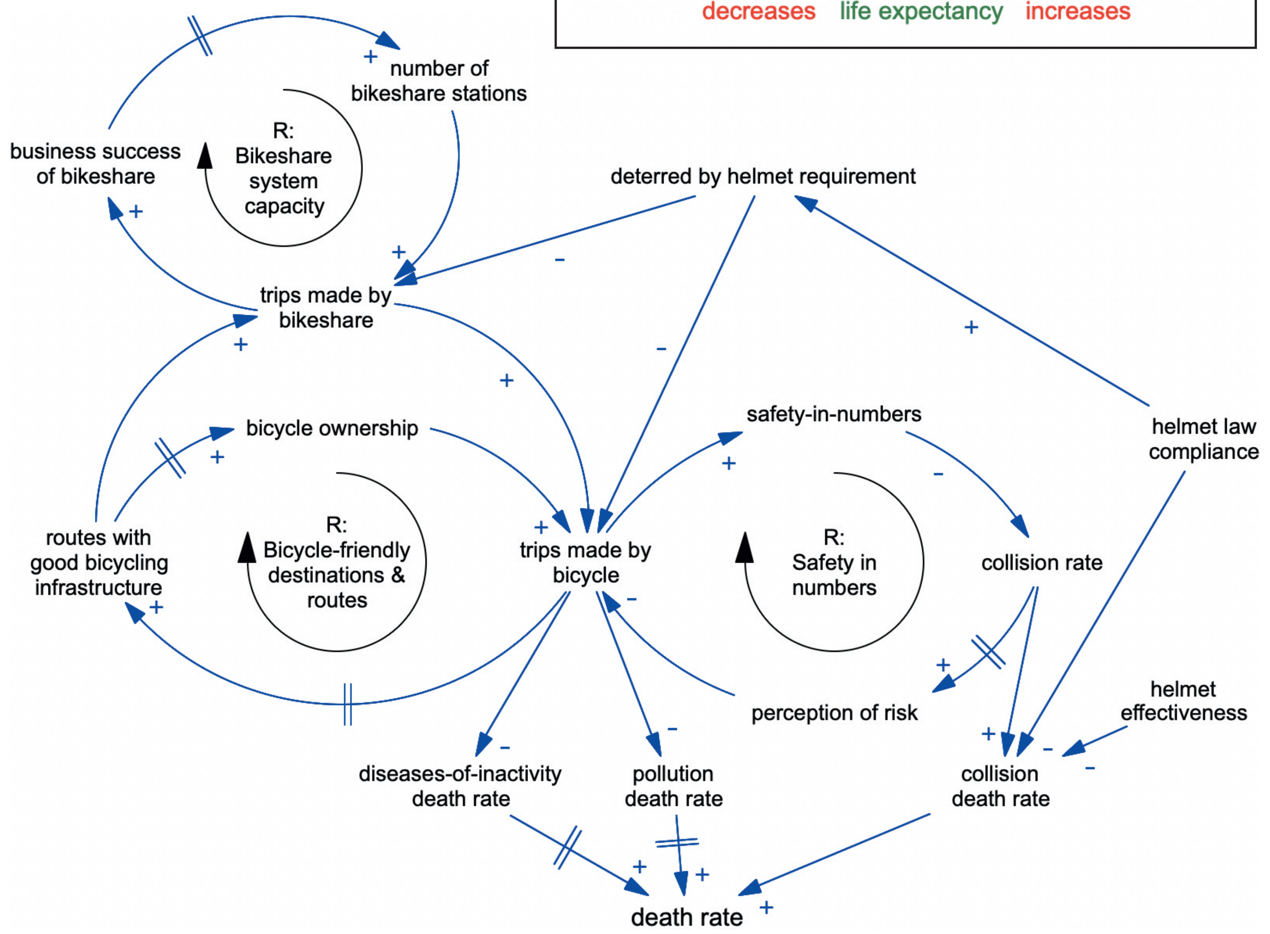
Purpose

Cyclist safety improves polynomially with the number of cyclists. Helmet laws protect cyclists in collisions, and reduce the number of trips by bicycle. We explore possible dynamics in which these short-term effects activate longer-term feedbacks, impacting population-wide life expectancy.

Mobility technology ⇆ Death rate

Life expectancy increases due to the exercise provided by bicycling, and decreases due to fatal collisions.





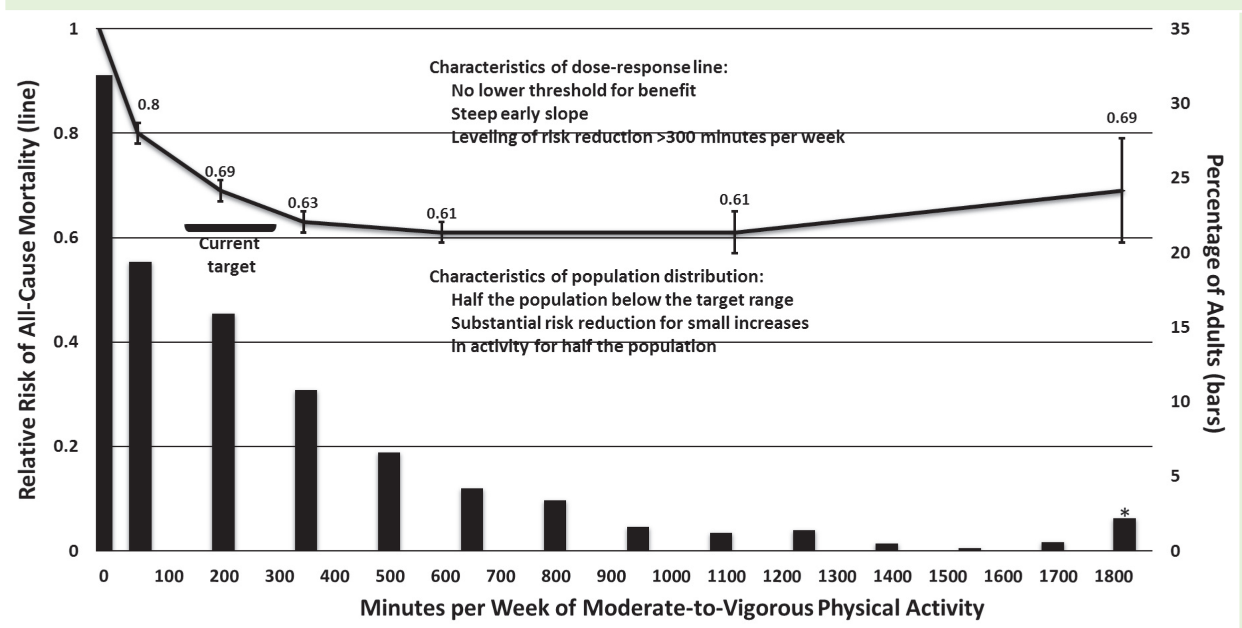
Mobility and Health

WHO guideline: ∼150–300 minutes/week of light–moderate exercise.
Typical mobility needs: ∼150–300 minutes/week.
Expected outcome: Every hour of bike commuting (light exercise) yields:

Movement: increases life expectancy by ∼3 hours.

Even greater increase to healthspan (QALY / DALY / LEGPH) and wellbeing: exercise prevents, cures, slows, mitigates ∼80% of diseases (weighted by popularity), slows ageing.

Fatal collision: the possibility decreases life expectancy by ≲ 5 minutes.



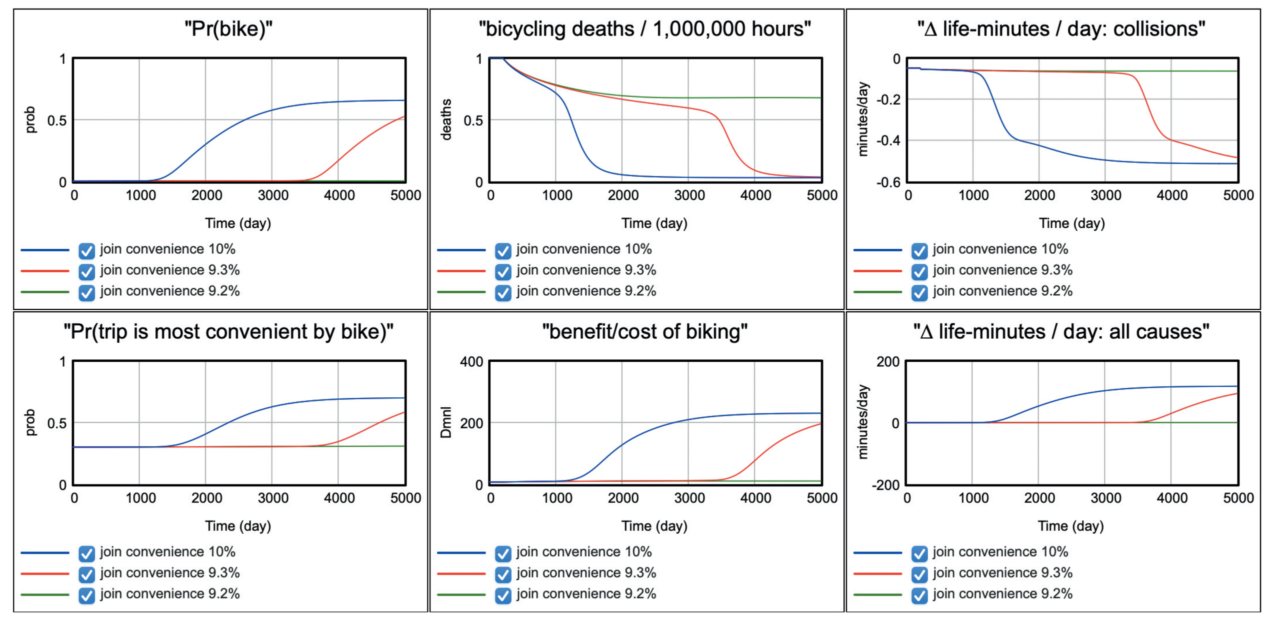
From: *2018 physical activity guidelines advisory committee scientific report.* Department of Health and Human Services., USA, 2018. ISSN 1753-4887

Introducing a bikeshare: s-curve growth?

Starting with ∼1% of trips being made by (personal) bike, on day 200 we introduce a bikeshare within easy reach of ∼8% of the population. The system improves slowly at first, followed by s-curve growth as the feedback loops activate each other.

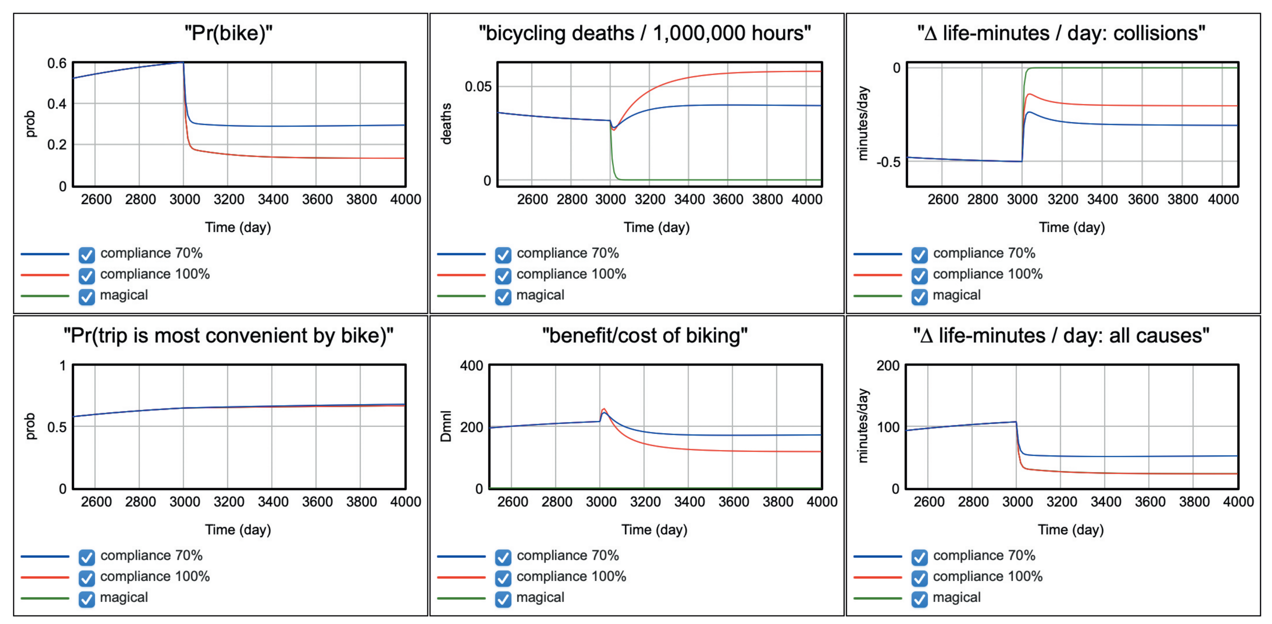
The system is sensitive to many parameters. Here we vary the convenience (probability) of joining the bikeshare. As this is reduced from 10%, the dynamics change gradually at first, but a sharp boundary appears around 9.3%, below which the bikeshare system does not attract enough members to maintain itself or stimulate significant infrastructure improvements.

- Δ *life-minutes / day: collisions:* 2× more bicycling leads to $2^{\beta}\times$ more crashes (e.g. $\beta = 0.4 \rightarrow 2^{0.4} \sim 1.32$) (risk reduced by $\frac{1}{3}$)
- Δ *life-minutes / day: all causes:* combining life expectancy change due to traffic deaths, air pollution, and light exercise from cycling.



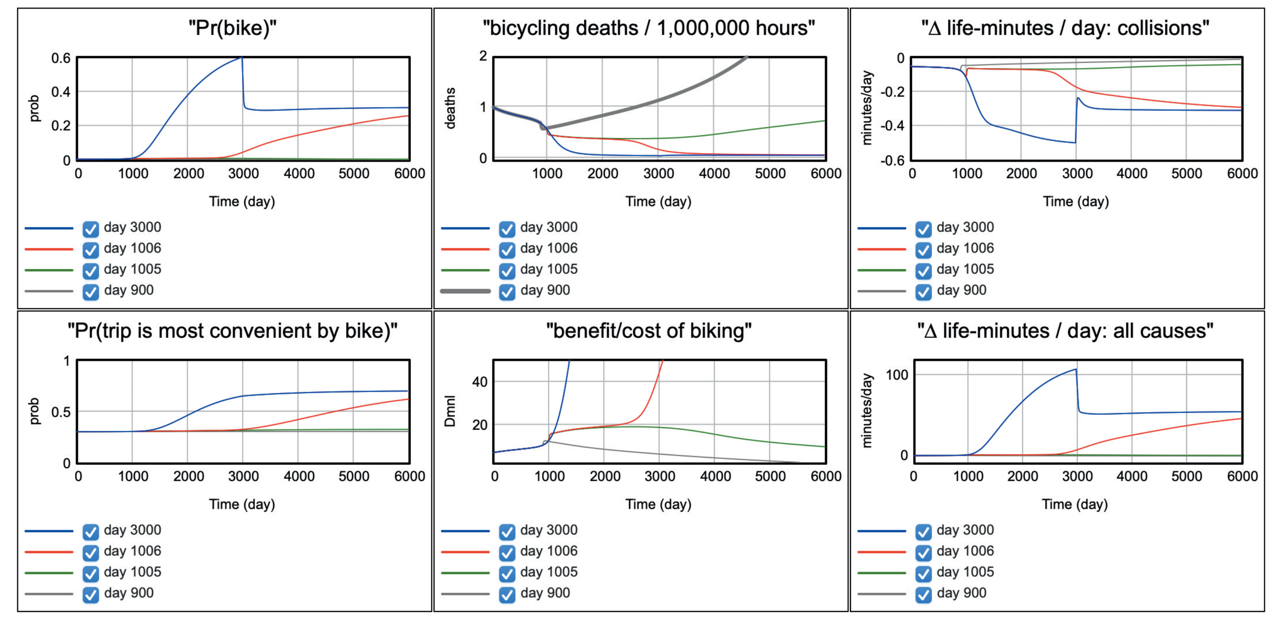
Introducing a helmet law

Behaviour is shown with 70% and 100% compliance with the law. Also shown: a "magical" scenario, with 100% compliance and helmets that prevent 100% of cycling deaths. For most of the output variables—notably "Δ life-minutes / day: all causes"—the magical scenario is almost indistinguishable from "100% compliance" with idealised helmets that give perfect protection from the ∼25% of collisions that involve head injuries.



Bistability

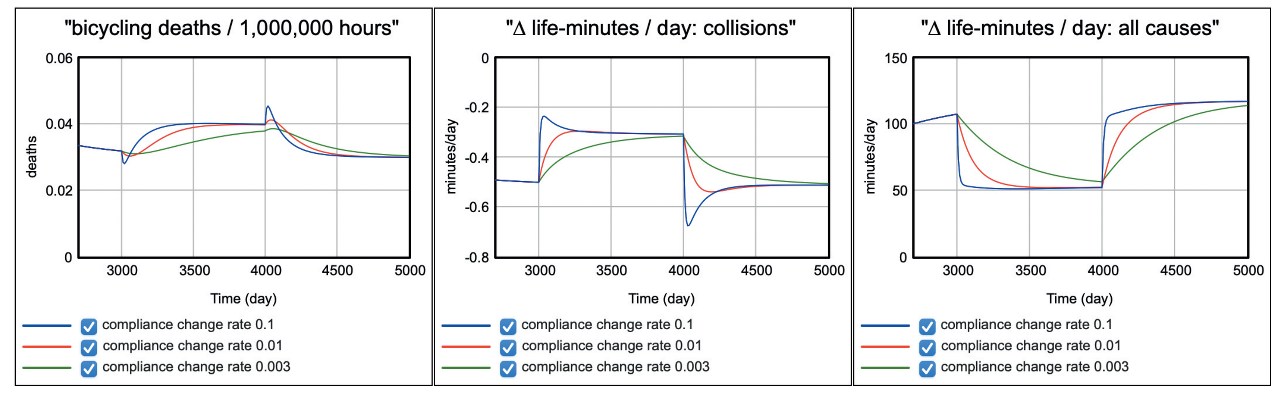
If a helmet law is introduced after a robust biking culture is established, the new law will damage public health, but the damage may be limited. However, such a law can also drive the system into the car-centric attractor. Here, if the bikeshare system has grown for 1006 days, then the helmet law merely reduces the benefit, but if the law is introduced one day earlier, then cycling culture collapses.



Repeal: dangerous—but only for politicians?

A helmet law is introduced on day 3000 (70% compliance) and repealed on day 4000. The repeal leads to an increase in the absolute number of fatalities (if $\beta > 0$), largely due to more cyclists.

If behavioural response to the law adjusts faster than safety-in-numbers effects, then there is also a brief period of higher exposure-adjusted risk. This worse-before-better behaviour disappears if the behavioural response rate is low. Policy hack?



Conclusions

Infrastructure improvements and helmets are often seen as complementary, but they can work against each-other:

Helmet laws—assuming perfect helmets:

- Extend life expectancy by ≲ **1 week.**
- Suppress feedback loops that encourage cycling.

Encouraging cycling:

- Activates virtuous safety–convenience feedback loops
- Increases safety polynomially → factors > 1000%?
- Decreases burden of diseases of inactivity.
  - Extends (healthy!) life expectancy by ∼ **1–4 years.**

Helmet policies can yield small short-term gains while preventing large long-term gains from safety-in-numbers effects.

→ *Treat helmet policies with extreme caution!*