Parental attitudes and beliefs about vaccines: unexpected effects of a vaccination campaign against hepatitis B

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Research Question (1)

- Vaccination against an infectious disease is an individual choice or a parental decision with collective implications
- Individuals decision-making regarding vaccination may be affected by the vaccination choices of others
- Public policies need to anticipate the reactions of individuals to a vaccination campaign
  - If everyone refuses to be vaccinated, the disease continues to spread and will never be eradicated.
  - On the contrary, vaccination can slow down the propagation of the disease

Research Question (2)

- Previous studies have highlighted the differences in individual reactions to a vaccination campaign:
  - Recommendations vs mandatory vaccination (Lawler, 2017; Abrevaya and Mulligan, 2011).
  - Vaccination campaigns may have side effects or spillover effects (Moghtaderi and Dor, 2016; Carpenter and Lawler, 2017).
  - The role of information seems to be determinant in vaccination acceptance (Chamoux 2006, Bruneau et al., 2001, and Laurence et al., 2013).
  - The effectiveness of vaccination policies may depend on the population targeted (Baguelin et al., 2010; Denis et al., 2004)
- Anderberg et al. (2011) and Chang (2018) analyze reactions consecutive to the MMR controversy (link with autism) in the UK and the US respectively.
  - they find an immediate decline of MMR vaccination rate
  - negative spillovers onto other vaccines
  - heterogeneity effects in the response to the MMR controversy depending on the educational level

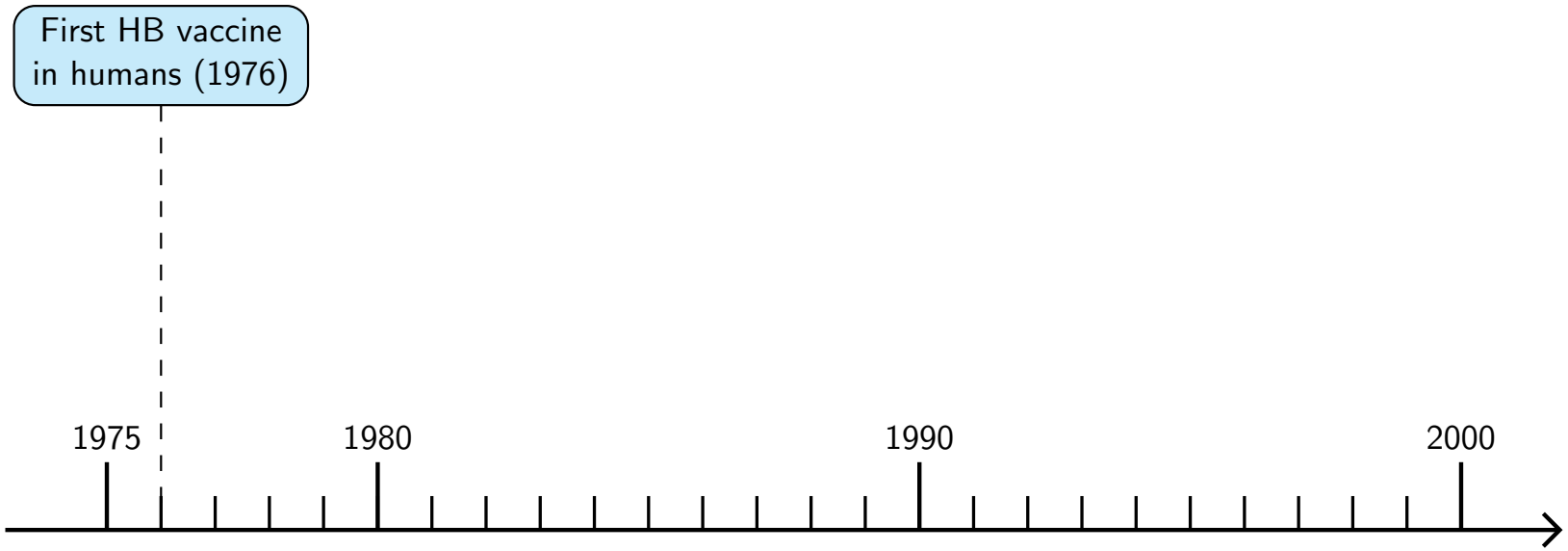
Research Question (3)

- We measure the effects of a HB vaccination campaign at school in France on:
  - Vaccination behaviours:
    - HB vaccination rates for children (adherence to the campaign)
    - MMR vaccination rates for children (spillovers onto other vaccines)
    - HB vaccination for parents (positive spillovers on parental vaccination)
  - Parental beliefs/information
    - about the targeted population (newborns, middle school children, the whole population)
    - about seriousness of diseases (MMR, HB)
- HB is an infectious disease leading to chronic disease with a risk of death from cirrhosis and liver cancer.
  - Transmission through sexual relations and blood, or at birth from the mother to the child (Wright and Lau, 1993).

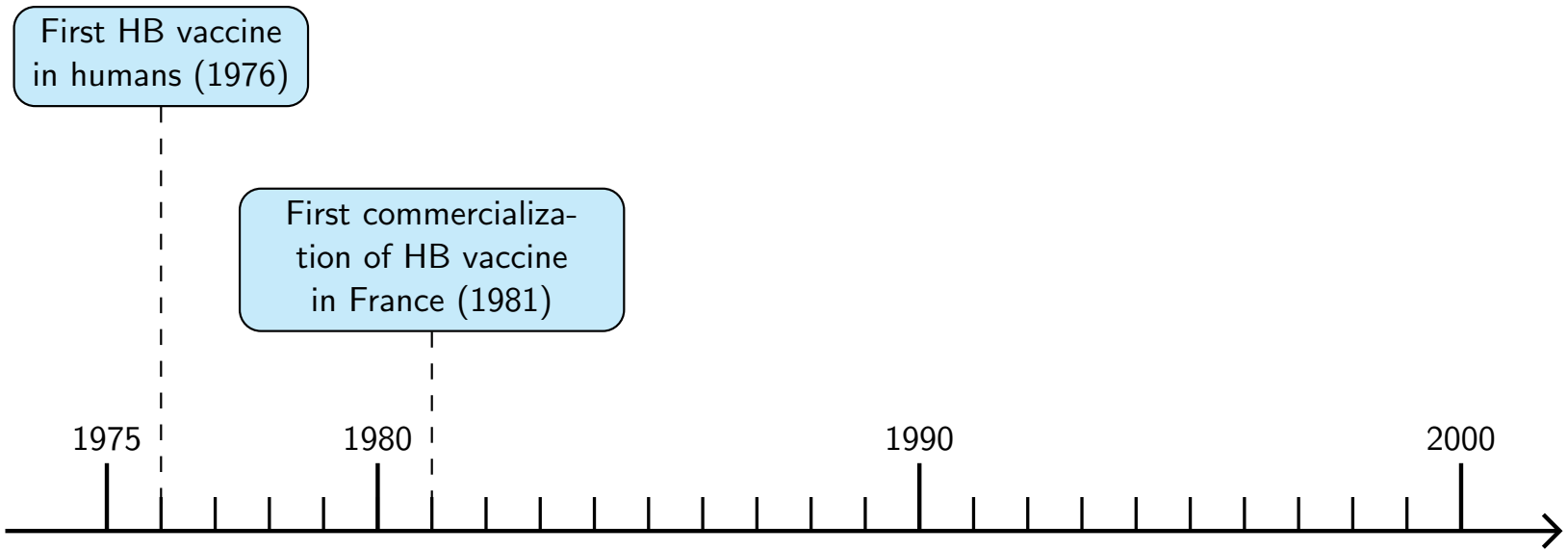
The 1994 French Vaccination Campaign

- In 1992, the WHO recommended HB vaccination for the newborn and all teenagers (in countries with low endemicity).
- In 1994, the Health Minister announced a massive and national HB vaccination campaign, which was implemented in 2 main steps:
  1. In June 1994: a major HB communication campaign $\rightarrow$ mainly directed towards young people via TV, radio, distribution of leaflets.
  2. From September 1994: a free vaccination campaign for children enrolled in middle-school.
- After the launch of this campaign, HB vaccine was held responsible for causing multiple sclerosis. Some articles were then published in the French press from 1996.

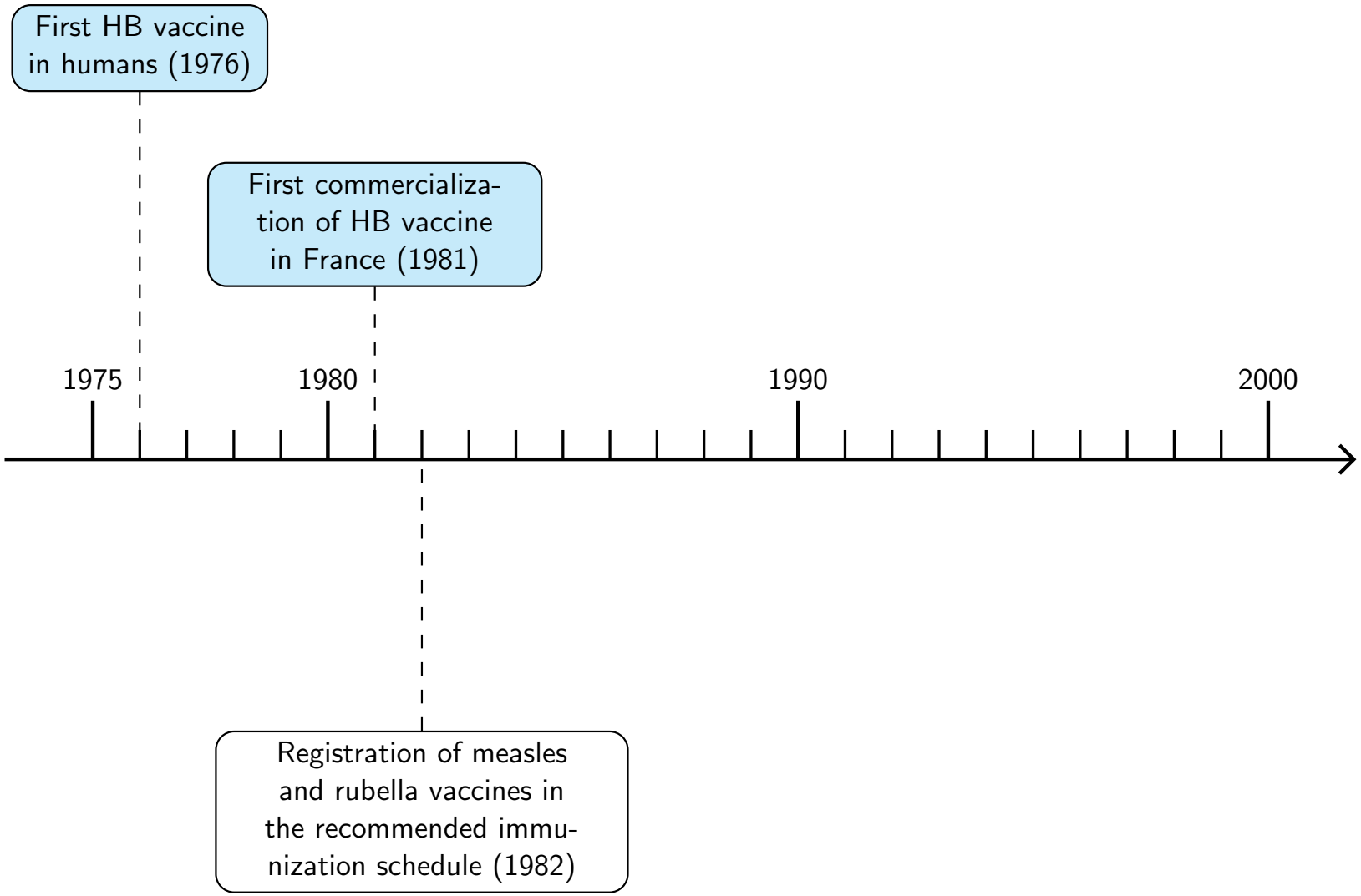
The 1994 French Vaccination Campaign



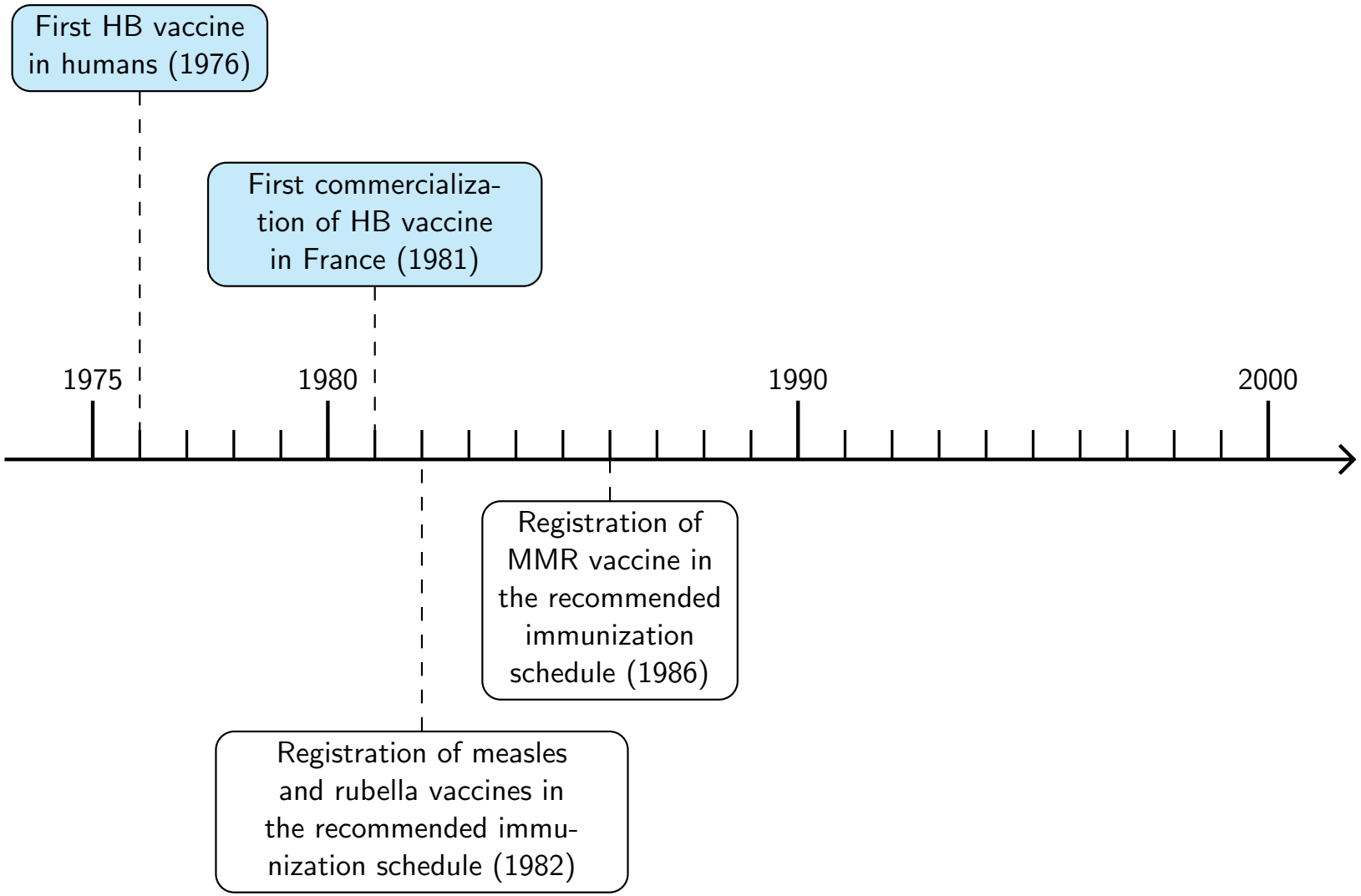
The 1994 French Vaccination Campaign



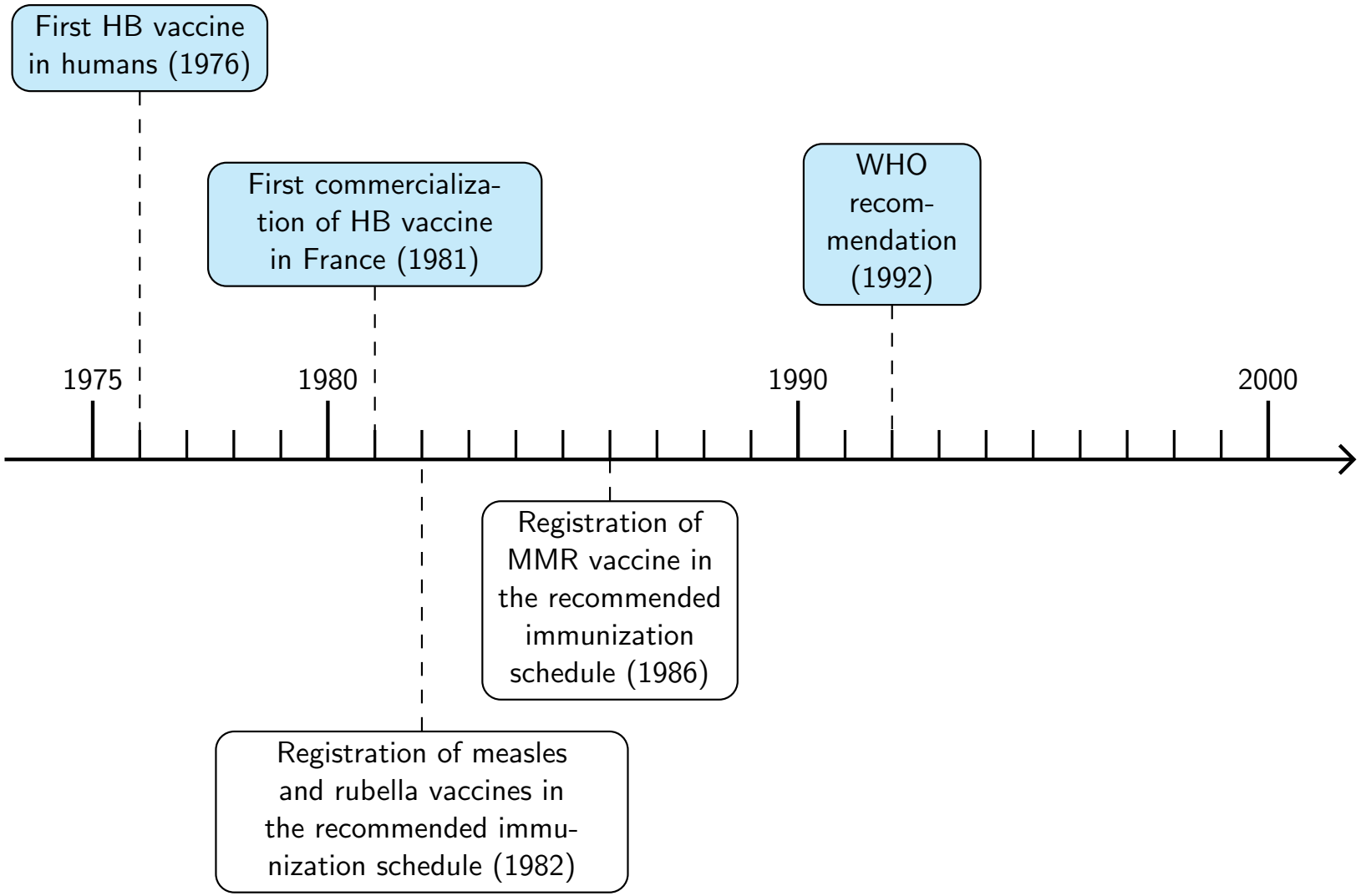
The 1994 French Vaccination Campaign



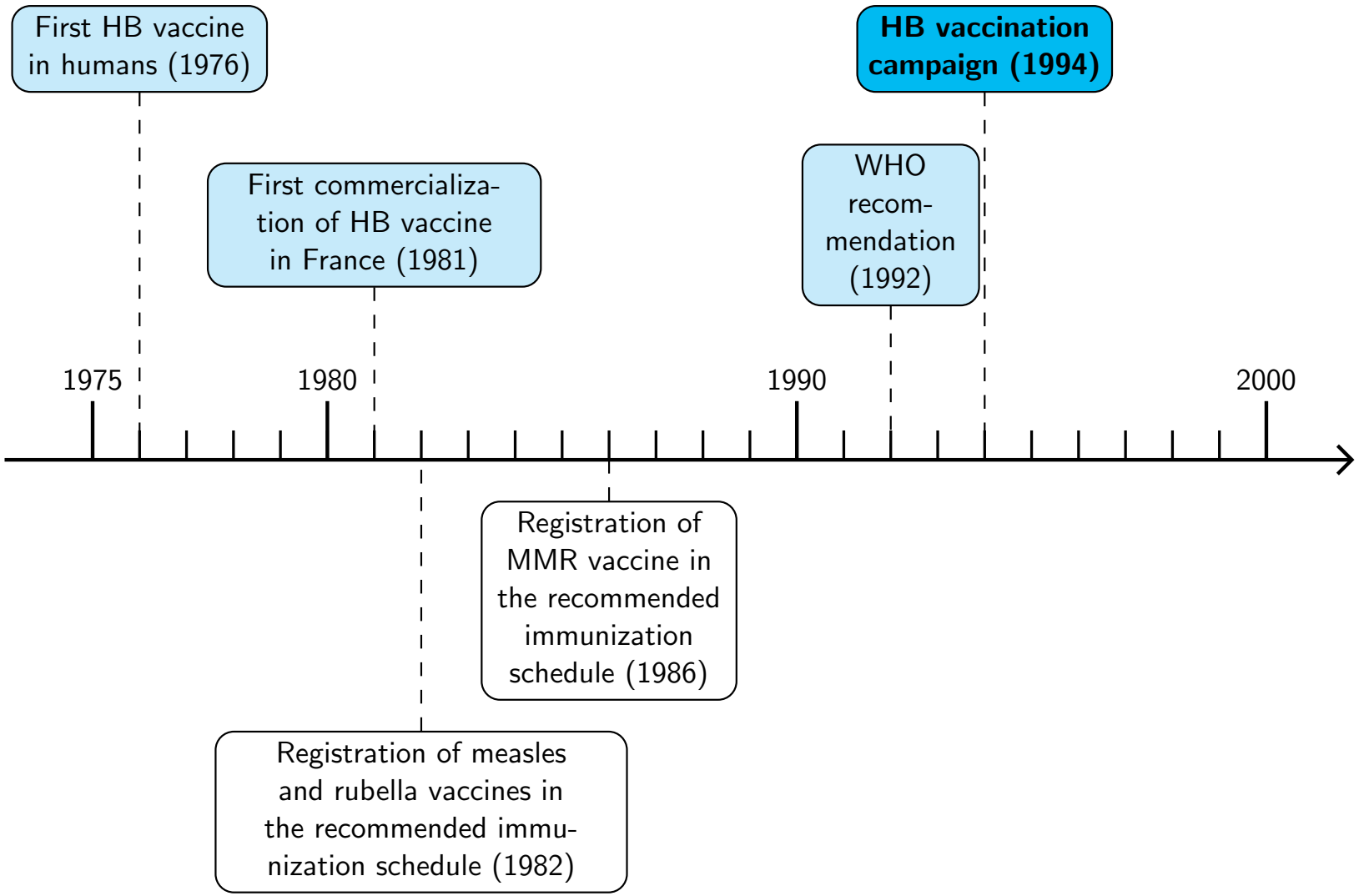
The 1994 French Vaccination Campaign



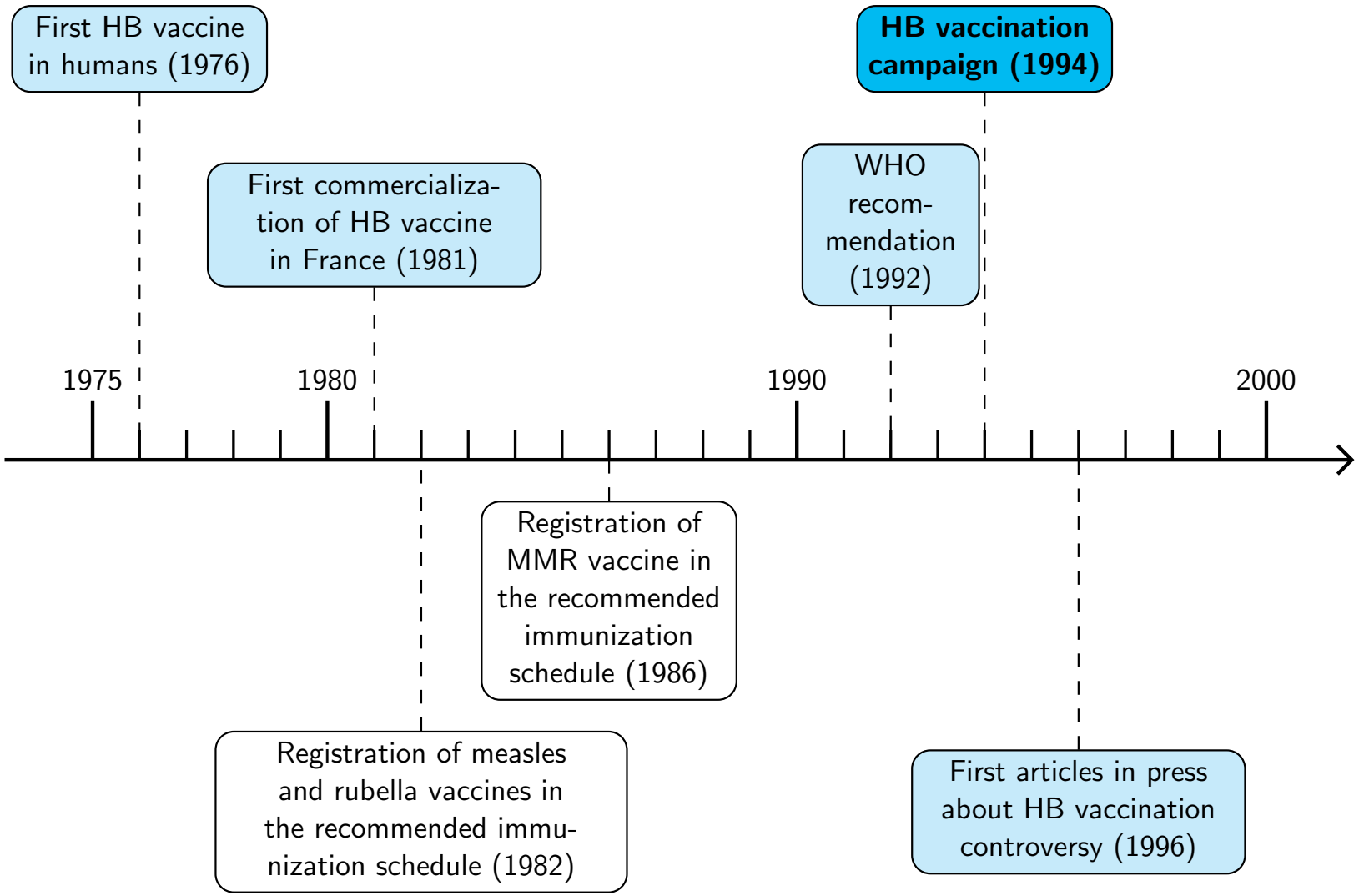
The 1994 French Vaccination Campaign



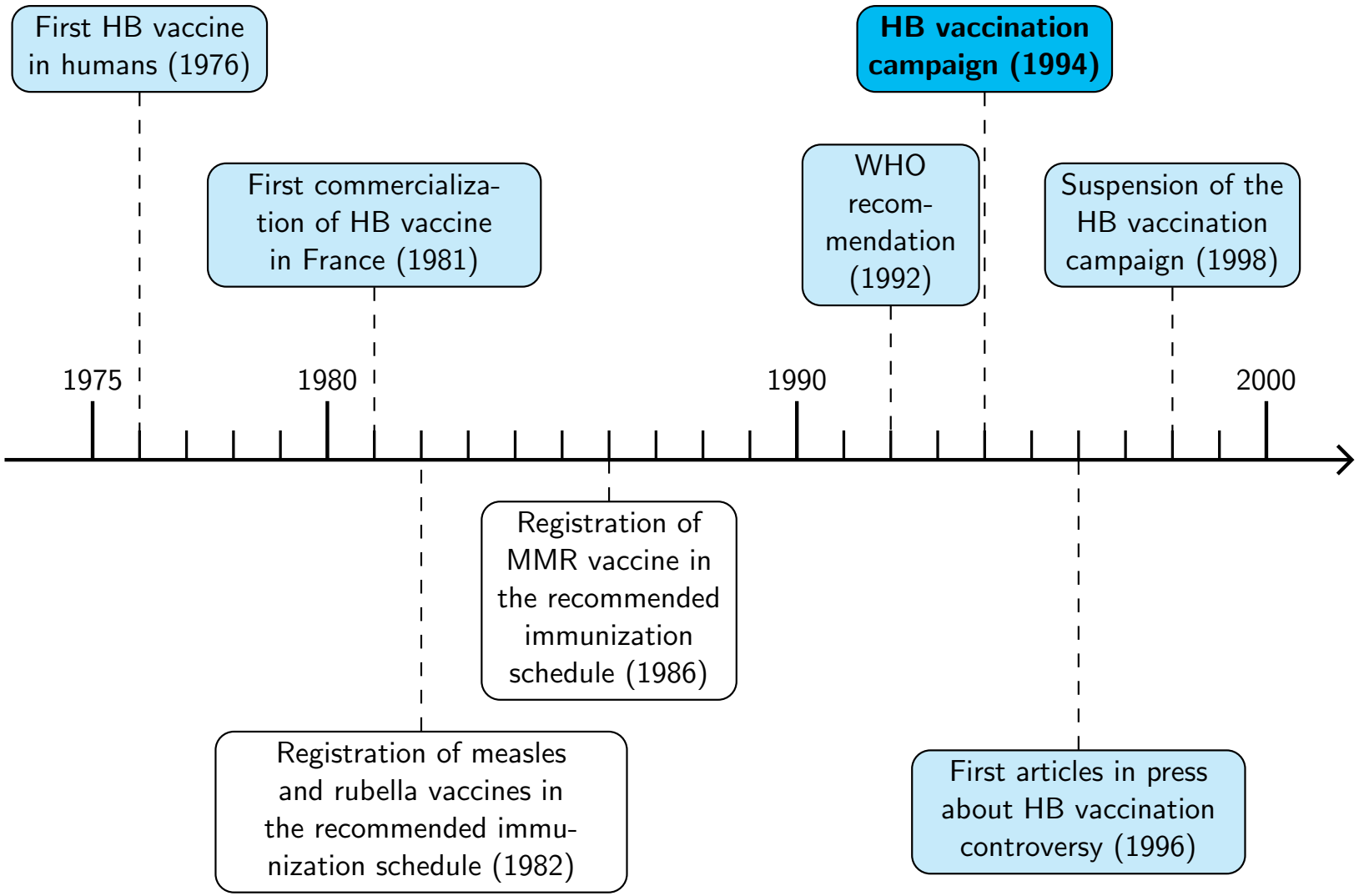
The 1994 French Vaccination Campaign



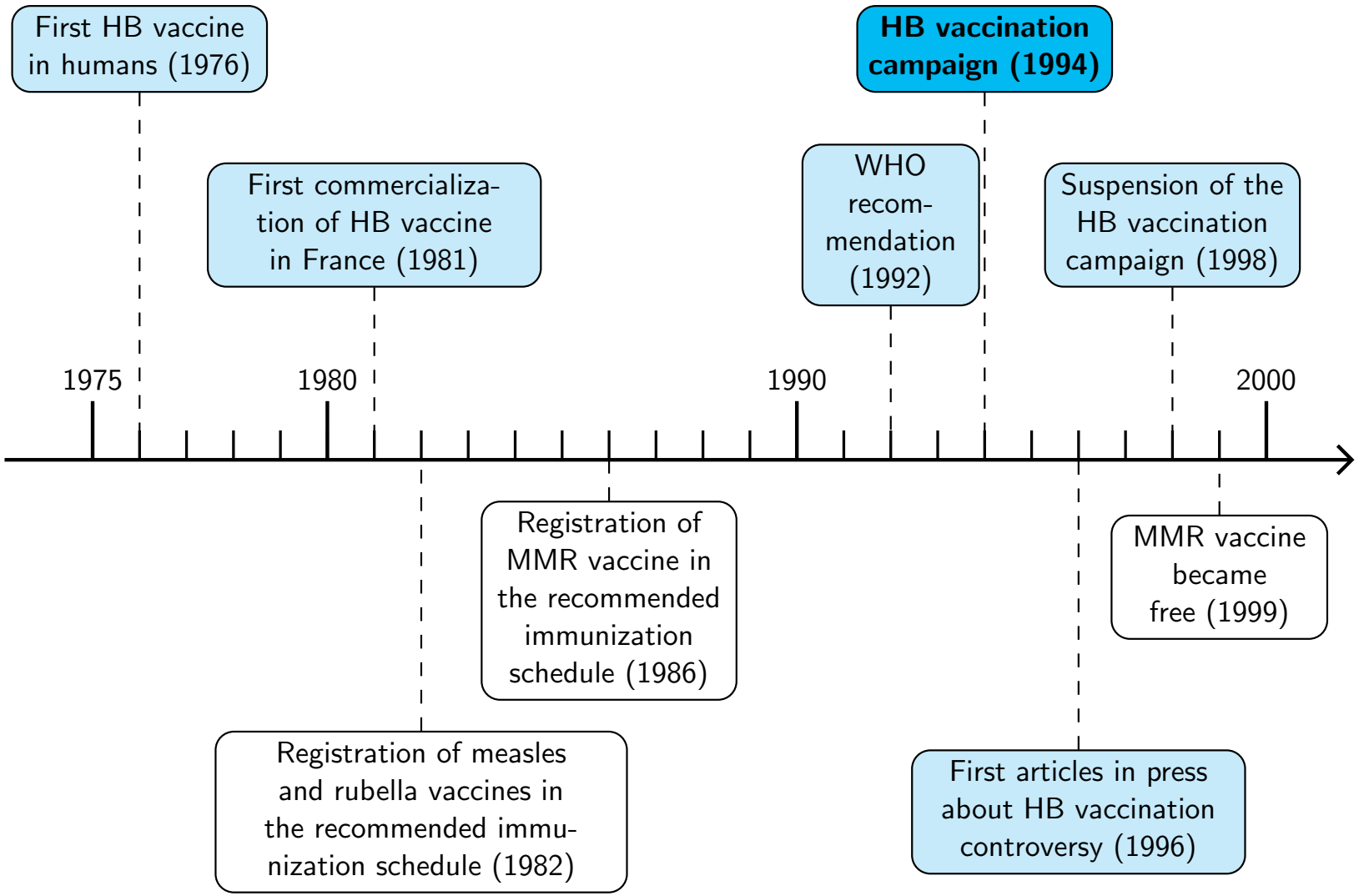
The 1994 French Vaccination Campaign



The 1994 French Vaccination Campaign



The 1994 French Vaccination Campaign



Data (1)

- The 1995 Health Barometer, a periodic survey, representative of the French population and collected by the French National Public Health Agency
- Data collection took place in November and December 1995
- The data set contains information concerning parents and children still living at home:
  - information on socio-demographics characteristics (sex, age, education, socio-professional category, etc.)
  - information on vaccination behaviors for different vaccines of children (MMR, HB vaccines), beliefs of parents about vaccination

Data (2)

- The campaign took place in 1995 (beginning in 1994):
  - **Treated**: composed of HH whose child was $\geq$ 11 years old
  - **Non-treated**: composed of HH whose child was $\leq$ 10
- Initial sample: N=1,993 households
  - keep only HH with at least one child
  - information on only or eldest child
- Final sample: 764 HH, 1 obs per only or eldest child in the HH

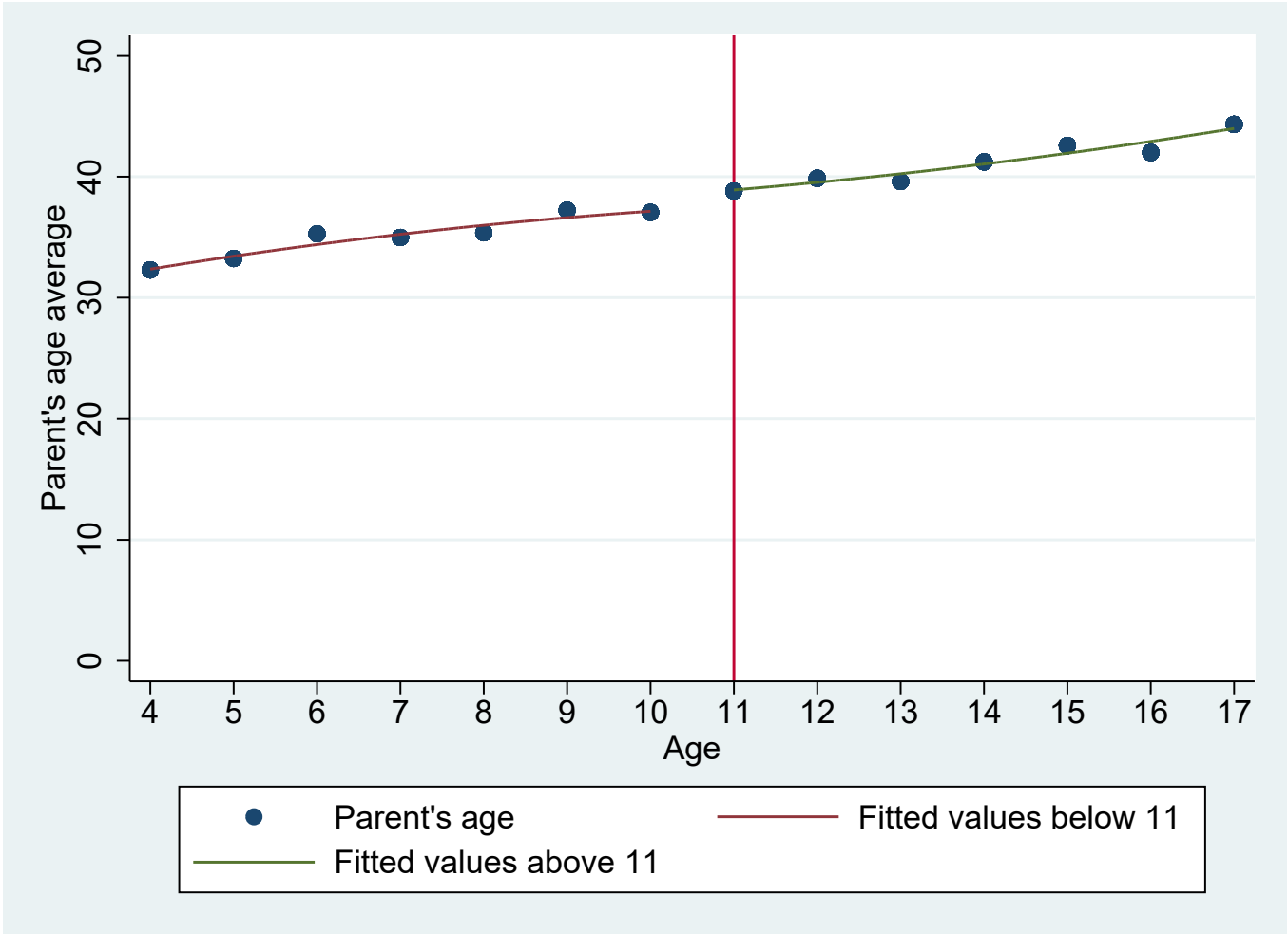
Descriptive Statistics (1)

Comparison of treated and non-treated groups, using a bandwidth of 5 years around the 11 threshold

Socio-demographics characteristics	(1) All sample Mean	(2) NT Mean	(3) T Mean	(4) T-test
male	0.39	0.36	0.38	0.02
parent's age	37.40	35.97	40.63	4.66***
French nationality	0.95	0.98	0.95	-0.03
high school diploma and more	0.41	0.43	0.34	-0.08
chronic diseases	0.22	0.18	0.25	0.07
executive	0.13	0.09	0.12	0.03
employee	0.17	0.15	0.22	0.08
blue collar worker	0.34	0.31	0.35	0.04
pensioner	0.01	0.00	0.02	0.02
other situation	0.01	0.02	0.01	-0.02

Note: ***Statistically significant at the 0.1% level; ** at the 1% level; * at the 5% level. For each variable, we include all possible observations, to maximize sample size. Columns (2) and (3) compute, respectively, the mean for households whose eldest child is between 6 and 10 years old (column (2)) and for those whose eldest child is between 11 and 15 years old (column (3)). Column (4) reports the test for equal means. Source: Health Barometer 1995.

Descriptive Statistics (2)



Descriptive Statistics (3)

Comparison of treated and non-treated groups, using a bandwidth of 5 years around the 11 threshold

Socio-demographics characteristics	(1) All sample Mean	(2) NT Mean	(3) T Mean	(4) T-test
urban	0.33	0.29	0.32	0.03
rural	0.30	0.36	0.31	-0.06
equalized income>1,500€	0.70	0.73	0.68	-0.06
married	0.89	0.91	0.85	-0.06
single	0.03	0.03	0.01	-0.02
separated	0.08	0.06	0.14	0.07*
one child	0.44	0.27	0.35	0.08
two children	0.39	0.50	0.40	-0.09
three children	0.14	0.20	0.19	-0.01
four children and more	0.03	0.02	0.05	0.02

Note: ***Statistically significant at the 0.1% level; ** at the 1% level; * at the 5% level. For each variable, we include all possible observations, to maximize sample size. Columns (2) and (3) compute, respectively, the mean for households whose eldest child is between 6 and 10 years old (column (2)) and for those whose eldest child is between 11 and 15 years old (column (3)). Column (4) reports the test for equal means. Source: Health Barometer 1995.

Descriptive Statistics (4)

Comparison of treated and non-treated groups, using a bandwidth of 5 years around the 11 threshold

Table 1: Parental attitudes about vaccination

Potential outcomes	(1) All sample Mean	(2) NT Mean	(3) T Mean	(4) T-test
Child vaccination:				
HB vaccination	0.52	**0.25**	**0.77**	0.52***
MMR vaccination	0.85	**0.93**	**0.80**	-0.13***
Parental vaccination:				
HB vaccination	0.32	0.38	0.29	-0.09

Note: ***Statistically significant at the 0.1% level; ** at the 1% level; * at the 5% level. For each variable, we include all possible observations, to maximize sample size. Columns (2) and (3) compute, respectively, the mean for households whose eldest child is between 6 and 10 years old (column (2)) and for those whose eldest child is between 11 and 15 years old (column (3)). Column (4) reports the test for equal means.
Source: Health Barometer 1995.

Descriptive Statistics (5)

Comparison of treated and non-treated groups, using a bandwidth of 5 years around the 11 threshold

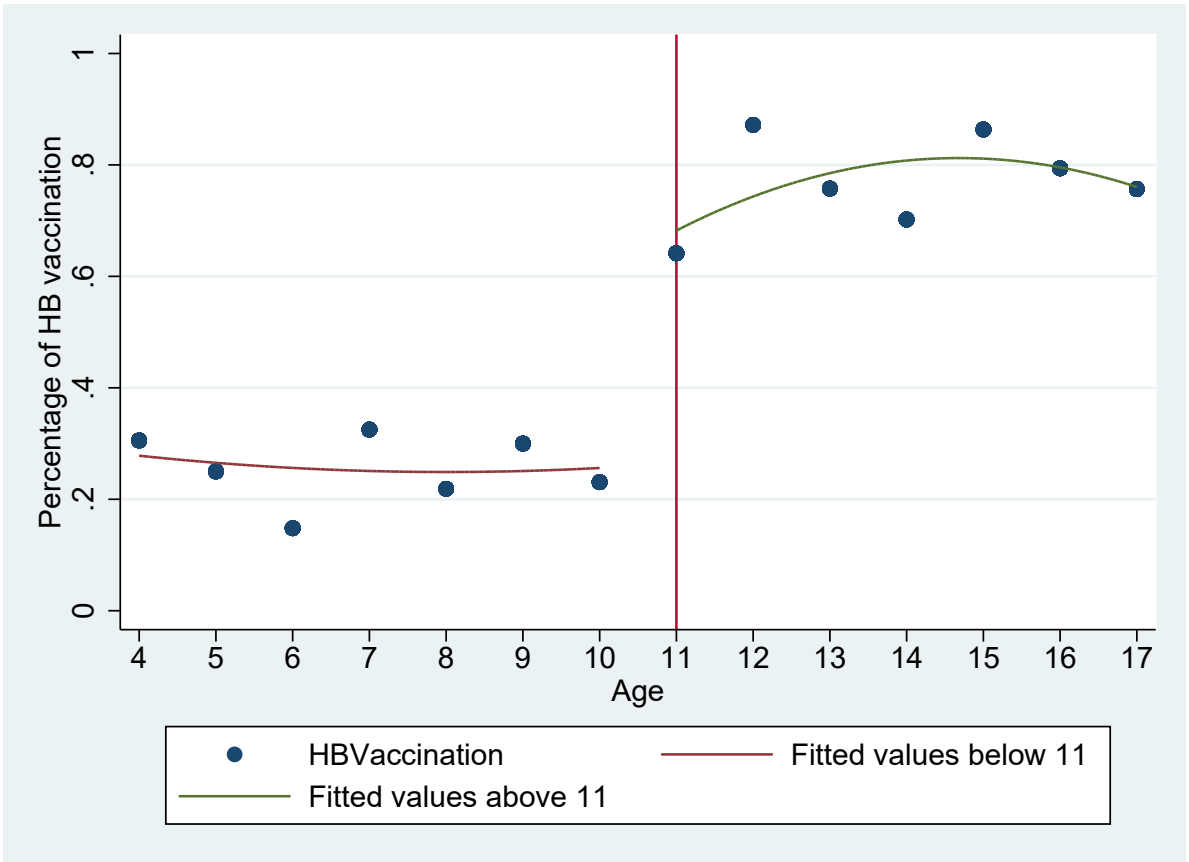
Table 2: Parental beliefs about vaccination

Potential outcomes	(1) All sample Mean	(2) NT Mean	(3) T Mean	(4) T-test
Parental beliefs:				
about the target population				
HB vacc. for newborns	0.55	0.57	0.52	-0.05
HB vacc. for middle school children	0.90	0.90	0.92	0.02
HB vacc. for the whole population	0.82	0.84	0.79	-0.04
about seriousness of diseases				
HB contamination knowledge	0.25	0.23	0.23	-0.00
MMR is a minor illness	0.35	0.31	0.36	0.06
trust in the MMR vaccine necessity	0.66	0.69	0.64	-0.05
HB is a serious illness	0.78	0.74	0.80	0.06

Note: ***Statistically significant at the 0.1% level; ** at the 1% level; * at the 5% level. For each variable, we include all possible observations, to maximize sample size. Columns (2) and (3) compute, respectively, the mean for households whose eldest child is between 6 and 10 years old (column (2)) and for those whose eldest child is between 11 and 15 years old (column (3)). Column (4) reports the test for equal means.
Source: Health Barometer 1995.

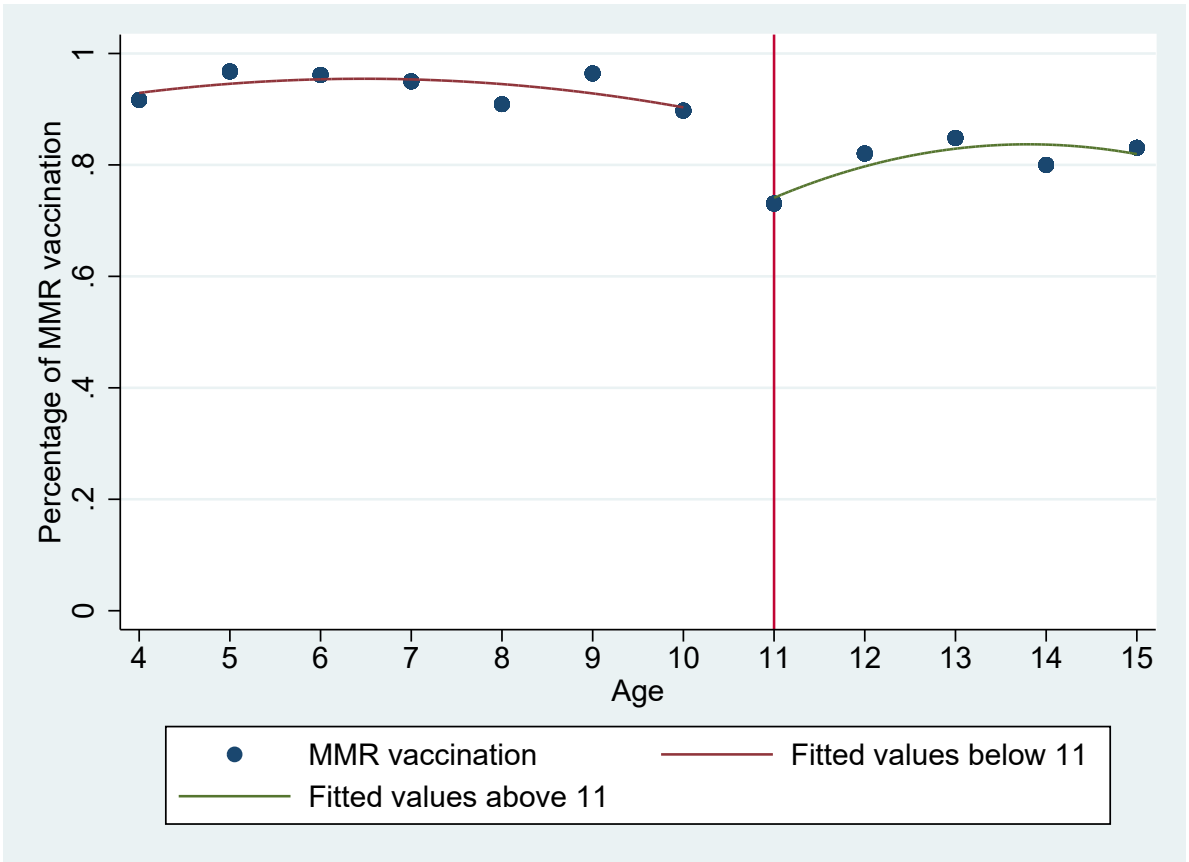
Graphical Evidence

Figure 1: Hepatitis B vaccination rate by age of only or eldest child



Graphical Evidence

Figure 2: MMR vaccination rate by age of only or eldest child



Empirical Strategy (1)

- We use the eligibility to the vaccination campaign to estimate a causal effect of the campaign on several outcomes.
  - Vaccination behaviours: Children HB and MMR vaccinations + parental vaccination
  - Parental outcomes: HB contamination knowledge, beliefs and vaccination knowledge
- Note that we do not estimate RDD in a fuzzy design (ie. the 2nd step that would estimate the impact of an increase in HB vaccination rates on several other outcomes). We do not impose that changes in the outcomes only result from a change in vaccination against HB.
- **RDD in a sharp design** shows the causal effect of the free vaccination scheme on several outcomes.

Empirical Strategy (2)

- From September 1994 on, free vaccination was offered to pupils starting their middle school, ie. to pupils aged 11 and more.
- Our identifying strategy exploits the sharp discontinuity in the probability of eligibility at the age of 11:

$$Y_i = a_0 + a_1 \mathbb{1}_{A_i \geq 11} + a_2 (A_i - 11) \mathbb{1}_{A_i \geq 11} + a_3 (A_i - 11) + u_i$$

with A_i the age of child $i (i = 1, ..., n)$, Y_i, all the potential outcomes.

- a_1 identifies the causal effect of the 1994 vaccination campaign at school on the potential outcomes.

Results (1)

RD estimates for behavior outcomes. Results obtained for children aged between 6 and 15 years old

Table 3: Parental attitudes about vaccination

	Child HB vaccination (1)	Child MMR vaccination (2)	Parental vaccination against HB (3)
$\mathbb{1}_{A_i \geq 11}$	0.42***	-0.13***	-0.00
se	(0.081)	(0.040)	(0.08)
N	406	394	409

Note: Standard errors in parentheses, clustered by age of the eldest child. ***Statistically significant at 1% level; **significant at 5% level; *significant at 10% level. We control by $(A_i - 11)\mathbb{1}_{A_i \geq 11}$ and $(A_i - 11)$. Source: Health Barometer 1995. Sample restricted to the oldest child of the household. Alternative specification

Results (2)

RD estimates for beliefs outcomes. Results obtained for children aged between 6 and 15 years old

Table 4: Parental beliefs about vaccination

	Knowledge about the targeted pop.		
	Newborns	Sixth grade pupils	All the population
	(1)	(2)	(3)
$\mathbb{1}_{A_i \geq 11}$	-0.277***	-0.022	-0.157***
s.e.	(0.049)	(0.032)	(0.015)
N	362	397	397

Note: Standard errors in parentheses, clustered by age of the eldest child. ***Statistically significant at 1% level; **significant at 5% level; *significant at 10% level.We control by $(A_i - 11)\mathbb{1}_{A_i \geq 11}$ and $(A_i - 11)$. Source: Health Barometer 1995. Sample restricted to the oldest child of the household. Alternative specification

Results (3)

RD estimates for belief and knowledge outcomes. Results obtained for children aged between 6 and 15 years old

Table 5: RD estimates for beliefs about the HB vaccination campaign. Results obtained for children aged between 6 and 15 years old

	HB contamination knowledge	**Seriousness of diseases**		
		HB is serious	MMR is benign	MMR non-vacc is risky
	(1)	(2)	(3)	(4)
$\mathbb{1}_{A_i \geq 11}$	-0.153***	0.02	0.20*	-0.16***
s.e.	(0.040)	(0.05)	(0.10)	(0.08)
N	406	411	407	406

Note: Standard errors in parentheses, clustered by age of the eldest child. ***Statistically significant at 1% level; **significant at 5% level; *significant at 10% level.We control by $(A_i - 11)\mathbb{1}_{A_i \geq 11}$ and $(A_i - 11)$. Source: Health Barometer 1995. Sample restricted to the oldest child of the household Alternative specification

Results (4)

Negative spillovers onto other vaccine: drop in the MMR vaccination rate

- We find an increase in children HB vaccination
- We find a decrease in children MMR vaccination
  - The households may be reluctance to administer both vaccines the same year.
  - Price effect? For households, the relative cost of the MMR vaccination increases compared to the free HB vaccination.
  - More probably salience effect: the focus on HB vaccination leads to a decrease in vaccination for non mandatory vaccines ("they are not so important otherwise, there would be a campaign for this vaccine, too")
- This result is consistent with the fact that treated individuals are less likely to believe that non-vaccination against MMR is risky for their child. They are also more likely to report that MMR is benign.

Results (5)

Non-significant effects on parental vaccination, belief that middle school children should have HB vaccination and belief that HB is a serious disease.

- The vaccination scheme did not have any impact on parental vaccination against HB (no positive spillovers effects on parental vaccination).
- We find a non-significant impact on belief that teenagers and sixth grade children should be vaccinated against HB.
  - This suggests that the whole population, whatever the age of the child, was aware that the campaign was first directed to children in middle-school.
- We find a non-significant impact on belief that HB is a serious disease.

Results (6)

Knowledge about the target population

Individuals with children aged 11 and above are less likely to believe than newborn babies and the whole population should be vaccinated.

- Given the WHO recommendations, the campaign also aimed at promoting vaccination for newborn babies and the entire population. This could indicate that the campaign was wrongly interpreted by individuals who had additional information at school.
- Individuals may have focused their attention on the necessity of teenage vaccination, obscuring the risk for other populations (newborns and the whole population), leading to the existence of a salience effect on the teenagers.

Results (7)

Decrease in knowledge about HB vaccination modes of transmission

There is a decrease in knowledge about the modes of contamination for treated household, i.e. those who have a child aged 11 and above.

- This can be the result of the disclosure of false information during the campaign.
- The Prime Minister claimed that this disease could be transmitted by saliva and this information was spread by some radios, however this is absolutely not the case (Sénat, 2001).
- Overall, the treated population may have been confused by contradictory information.

Robustness Checks (1)

Our main results are confirmed when:

- We use another bandwidth: 4 or 6 years around the age threshold, instead of 5
- We use a sample composed of all children in the HH (and not only the eldest one or the only one)
- We check that there is no discontinuity in measles vaccination rate depending on the cohort.
- We perform a Placebo test using the Health Barometer 2000 (the HB campaign is over). At the age of 11, we find:
  - no significant decrease in MMR vaccination rate
  - no significant decline in trust in vaccines
- We perform a Placebo test using the Health Barometer 1992 (before the HB campaign).
  - At the age of 11, we find: a positive impact
  - At the age of 8, we find: no significant impact

8

Robustness Checks (2)

Table 6: Placebo tests: RD estimates for MMR vaccination using 1992 and 2000 Health Barometers. Results obtained for children aged between 6 and 15 years old

Vaccination	Children MMR vaccination 1992 Health Barometer (1)	Children MMR vaccination 2000 Health Barometer (2)
$\mathbb{1}_{A_i \geq 11}$	0.19*	0.011
se	(0.09)	(0.015)
N	155	2066
$\mathbb{1}_{A_i \geq 8}$	-0.01	
se	(0.09)	
N	262	

Note: Standard errors in parentheses, clustered by age of the eldest child. ***Statistically significant at 1% level; **significant at 5% level; *significant at 10% level. We control by $(A_i - 11)\mathbb{1}_{A_i \geq 11}$ and $(A_i - 11)\mathbb{1}_{A_i < 11}$. Source: Health Barometer 1995.Health Barometer 2000. Sample restricted to the oldest child of the household.

Conclusion (1)

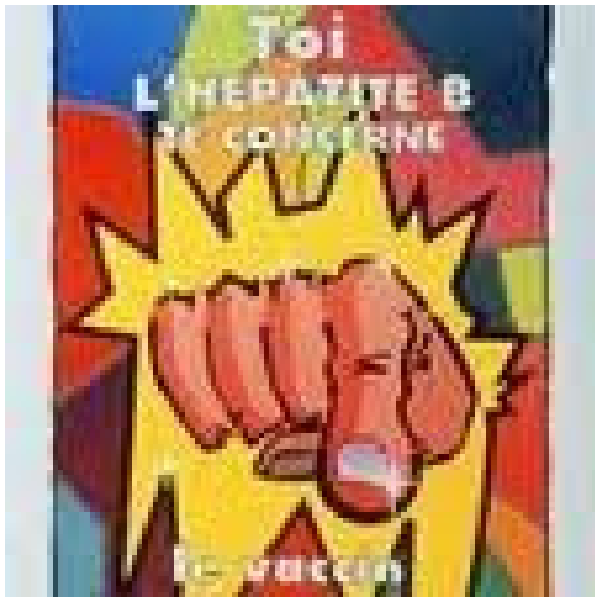
- We find that this vaccination scheme led to a strong increase in HB vaccination rates.
- However, the vaccination campaign, led to
  - non-significant effect on parental vaccination
  - $\downarrow$ in measles, mumps and rubella (MMR) vaccination rates
  - $\downarrow$ in knowledge about the mode of transmission
  - salience effects?
    - on the HB vaccination
    - on the teenagers population

Conclusion (2)

- The effect on MMR is unexpected and may imply a negative externality.
- Measles is an extremely contagious, potentially dangerous, disease. With a vaccination rate cover exceeding 95%, measles would be eradicated (Christie and Gay, 2011).
- If the vaccination rates falls, the disease will spread further, raising the question of the net effect of the HB vaccination campaign.
- A vaccination package may be a good option to avoid the salience effects.

Appendix

(a) 1994 archive: first national campaign (Ministère du Travail et des Affaires Sociales)



(b) archive 1994

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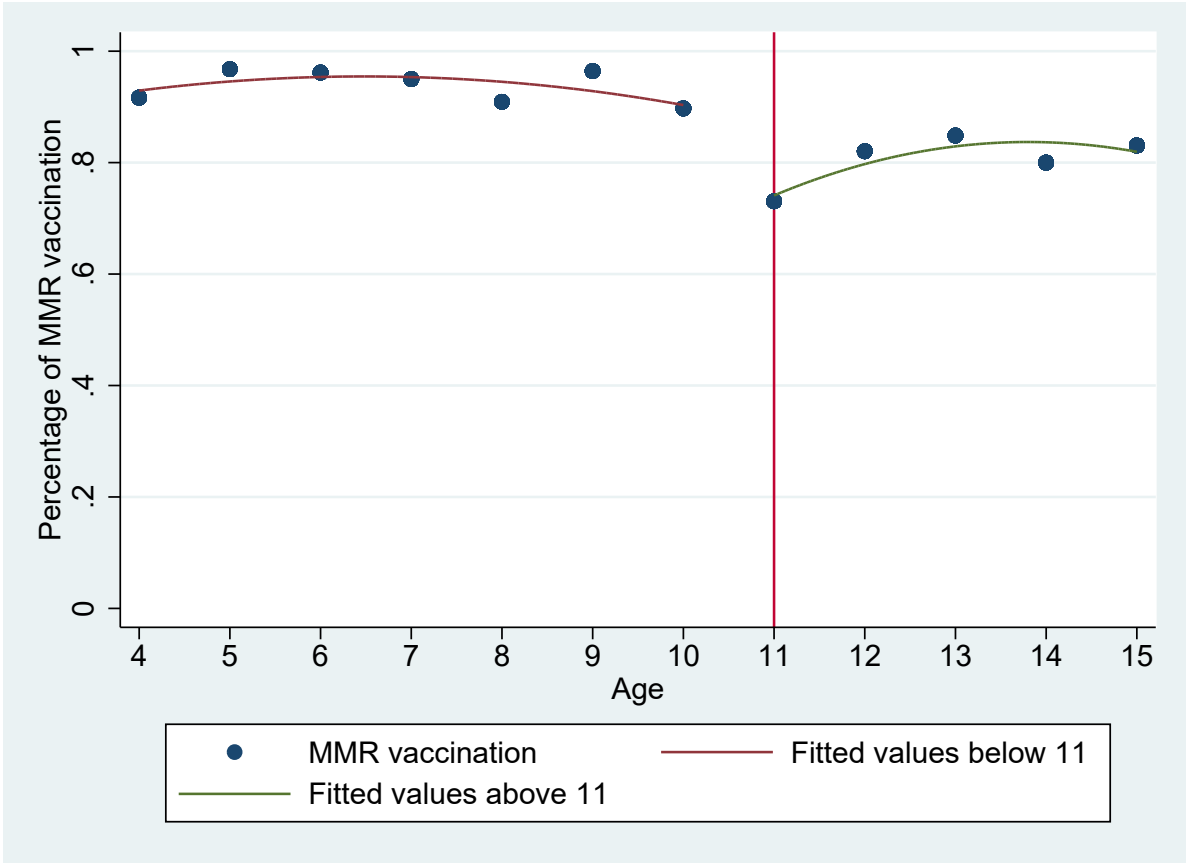
Figure A2: MMR vaccination rate by age of the first child



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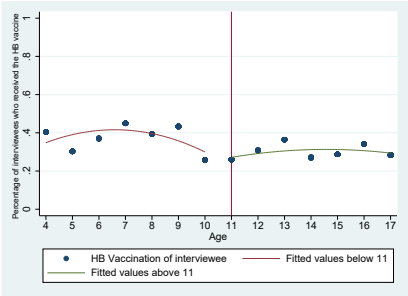
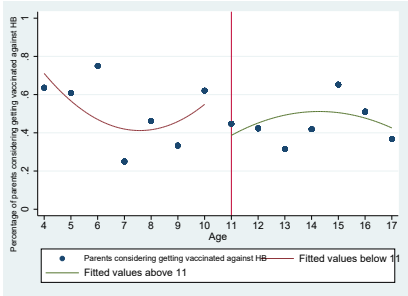
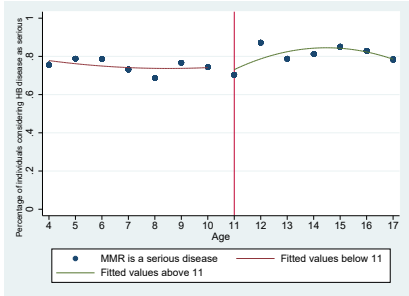


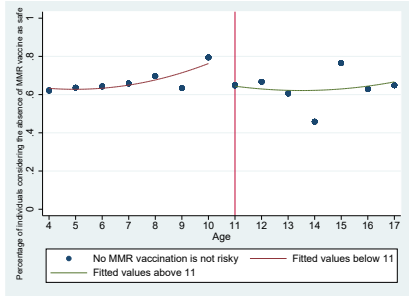
(a) HB parental vaccination



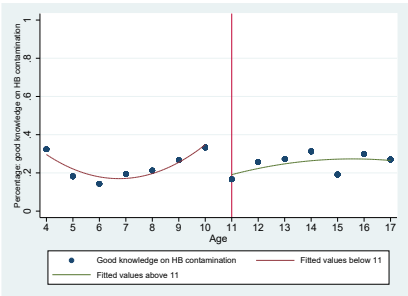
(b) Intention to be HB vaccinated



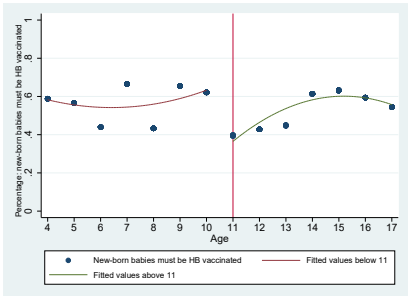
(c) HB is a serious illness



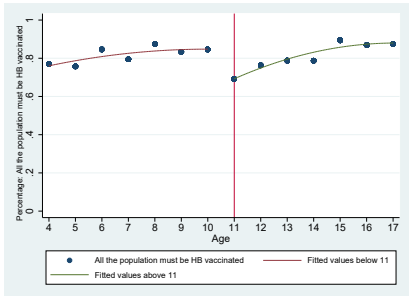
(d) Children MMR non-vaccination is risky



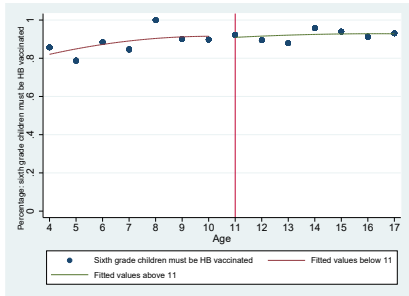
(e) HB cont. knowledge



(f) HB vaccination newborns



(g) population



(h) middle school

Figure A3: Relationship between children age and parental attitudes and beliefs

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Table A1: RD estimates using a bandwith of 5 years around the threshold of 11 years old – Attitudes about vaccination Back to the presentation

	Child vaccination against HB (1)	Child vaccination against MMR (2)	Parent vaccination against HB (3)
	Local Linear		
$\mathbb{1}_{A_i \geq 11}$	0.42***	-0.13***	-0.00
se	(0.081)	(0.040)	(0.08)
AIC	464.264	286.49	545.05
	Local Linear Spline		
$\mathbb{1}_{A_i \geq 11}$	0.49***	-0.15***	0.08
se	(0.092)	(0.039)	(0.06)
AIC	464.638	288.37	545.80
N	406	394	409

Note: Standard errors in parentheses, clustered by age of the eldest child. ***Statistically significant at the 1% level; **Statistically significant at the 5% level; *Statistically significant at the 10% level. Results obtained for children aged between 6 and 15 years old. We control by $(A_i - 11)\mathbb{1}_{A_i \geq 11}$ and $(A_i - 11)$, linear trends of age, continuous at the age of 11. $AIC = N \ln(\widehat{\sigma}^2_\epsilon) + 2p$.
Source: Health Barometer 1995. Sample restricted to the oldest child of the household.

Table A2: Parent's beliefs about the target population for HB vaccination

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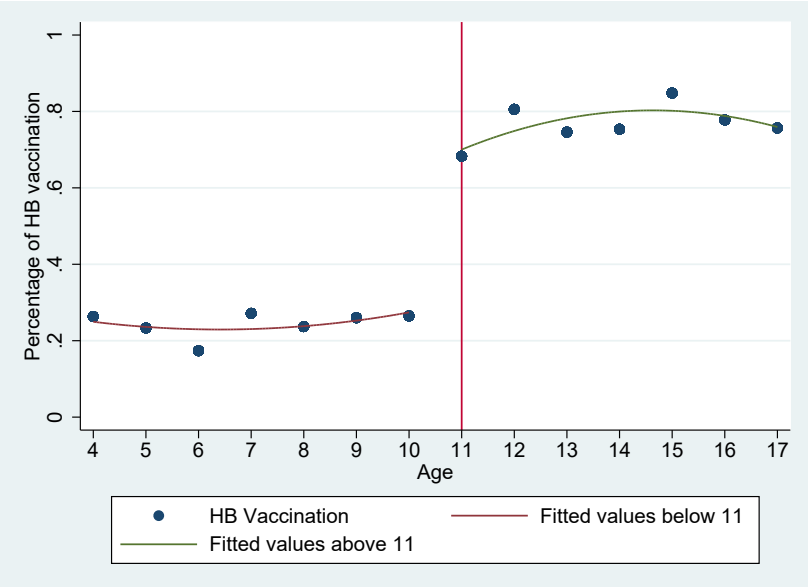
	The target population is...		
	Newborns	Middle school pupils	The whole population
	(1)	(2)	(3)
	Local Linear		
$\mathbb{1}_{A_i \geq 11}$	-0.277***	-0.022	-0.157***
s.e.	(0.049)	(0.032)	(0.015)
AIC	527.79	118.99	386.32
	Local Linear Spline		
$\mathbb{1}_{A_i \geq 11}$	-0.321***	0.050	-0.132***
s.e.	(0.078)	(0.036)	(0.025)
AIC	529.54	118.65	387.77
N	362	397	397

Note: Standard errors in parentheses, clustered by age of the eldest child. ***Statistically significant at the 1% level; **Statistically significant at the 5% level; *Statistically significant at the 10% level. Results obtained for children aged between 6 and 15 years old. We control by $(A_i - 11)\mathbb{1}_{A_i \geq 11}$ and $(A_i - 11)$, linear trends of age, continuous at the age of 11. $AIC = N \ln(\widehat{\sigma}^2_\epsilon) + 2p$. Source: Health Barometer 1995. Sample restricted to the oldest child of the household.

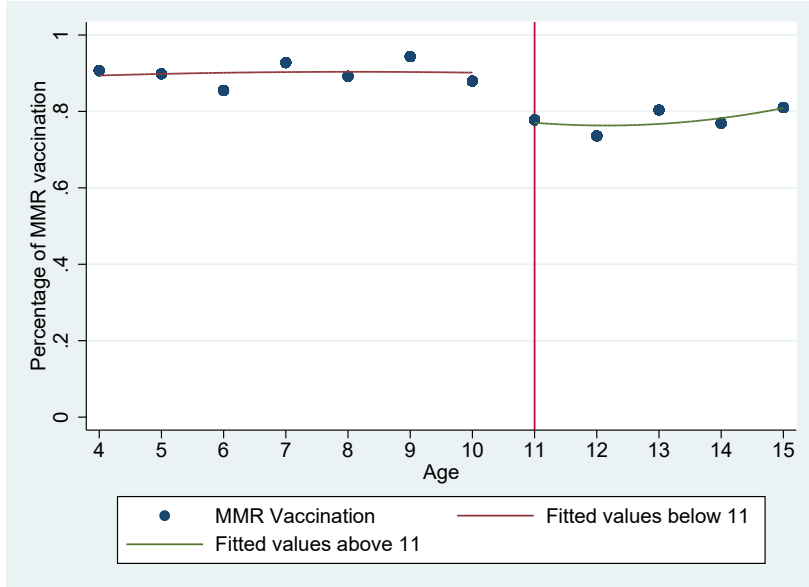
Table A3: RD estimates using a bandwith of 5 years around the threshold of 11 years old – Parent's beliefs about HB and MMR Back to the presentation

	HB contamination knowledge	**Seriousness of the disease**		
		HB is serious	MMR is benign	non MMR vacc is risky
	(1)	(2)	(3)	(4)
	Local Linear			
$\mathbb{1}_{A_i \geq 11}$	-0.15***	0.02	0.20*	-0.16***
s.e.	(0.040)	(0.05)	(0.10)	(0.07)
AIC	464.02	447.17	549.82	559.44
	Local Linear Spline			
$\mathbb{1}_{A_i \geq 11}$	-0.207***	-0.04	0.27**	-0.13*
s.e.	(0.016)	(0.05)	(0.11)	(0.06)
AIC	462.23	448.53	549.71	550.55
N	406	411	407	406

Note: Standard errors in parentheses, clustered by age of the eldest child. ***Statistically significant at the 1% level; **Statistically significant at the 5% level; *Statistically significant at the 10% level. Results obtained for children aged between 6 and 15 years old. We control by $(A_i - 11)\mathbb{1}_{A_i \geq 11}$ and $(A_i - 11)$, linear trends of age, continuous at the age of 11. $AIC = N \ln(\widehat{\sigma}^2_\epsilon) + 2p$.
Source: Health Barometer 1995. Sample restricted to the oldest child of the household.



(a) HB vaccination rates



(b) MMR vaccination rates

Figure A4: Relationship between children age and vaccination rates

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Evolution de la couverture vaccinale (CV) rougeole à 2 ans, 4 ans et 6 ans en fonction des cohortes de naissance 1979-1999, France (source : certificats de santé du 24ème mois et enquêtes en milieu scolaire, PMI et Drees)

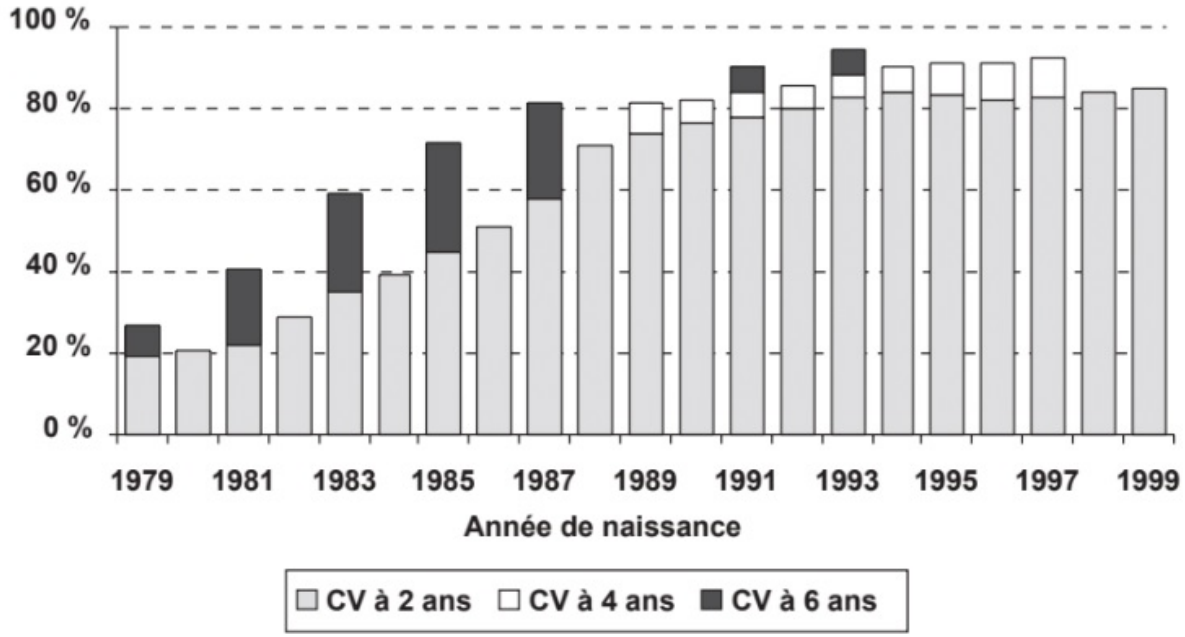

Figure A5: Relationship between measles vaccination and cohorts

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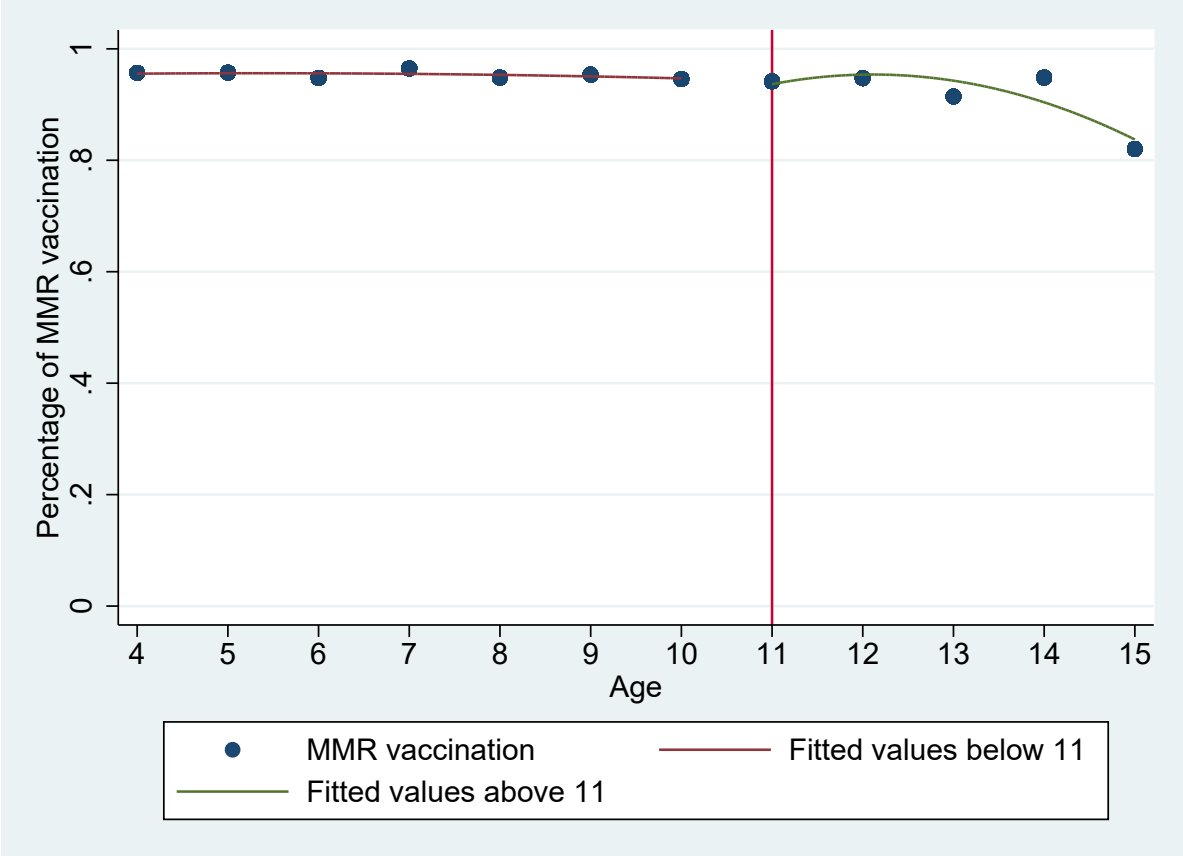

Figure A6: Relationship between children age and MMR vaccination (Health Barometer 2000)

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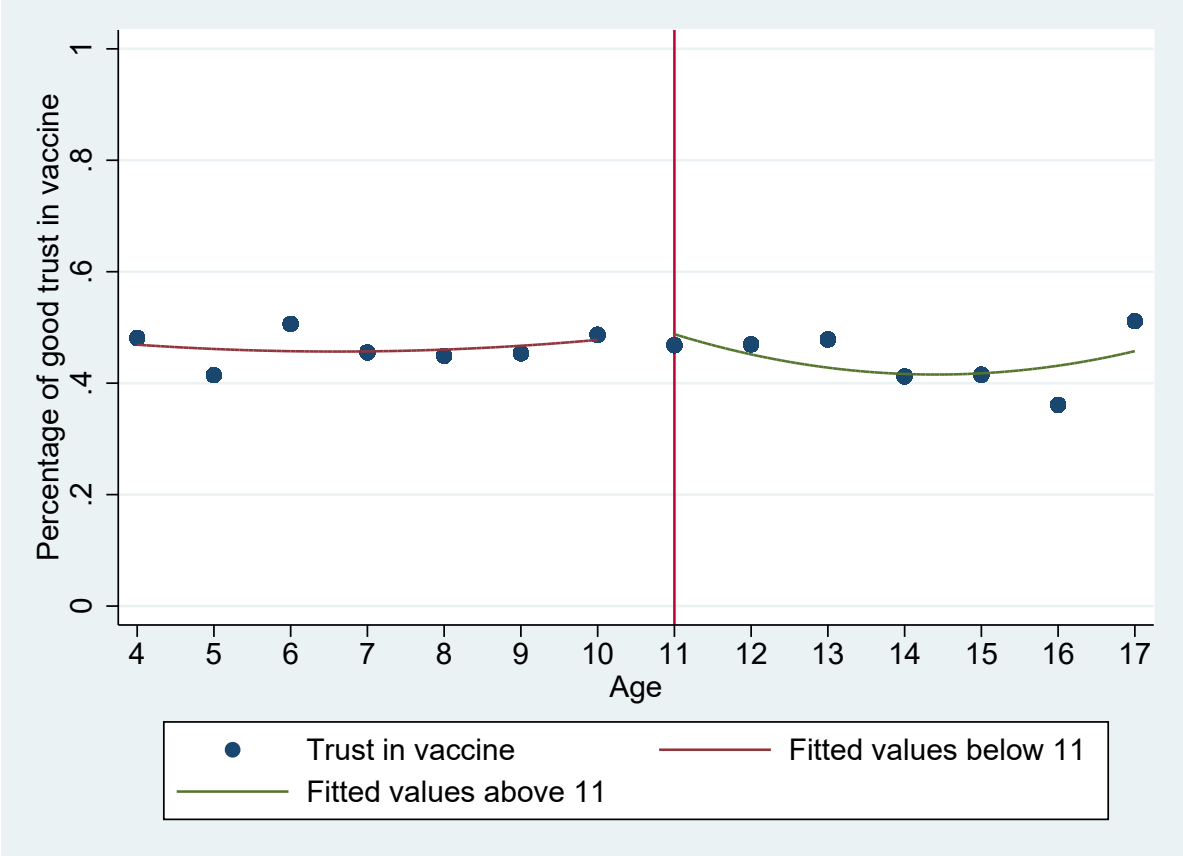

Figure A7: Relationship between children age and confidence in vaccination (Health Barometer 2000)

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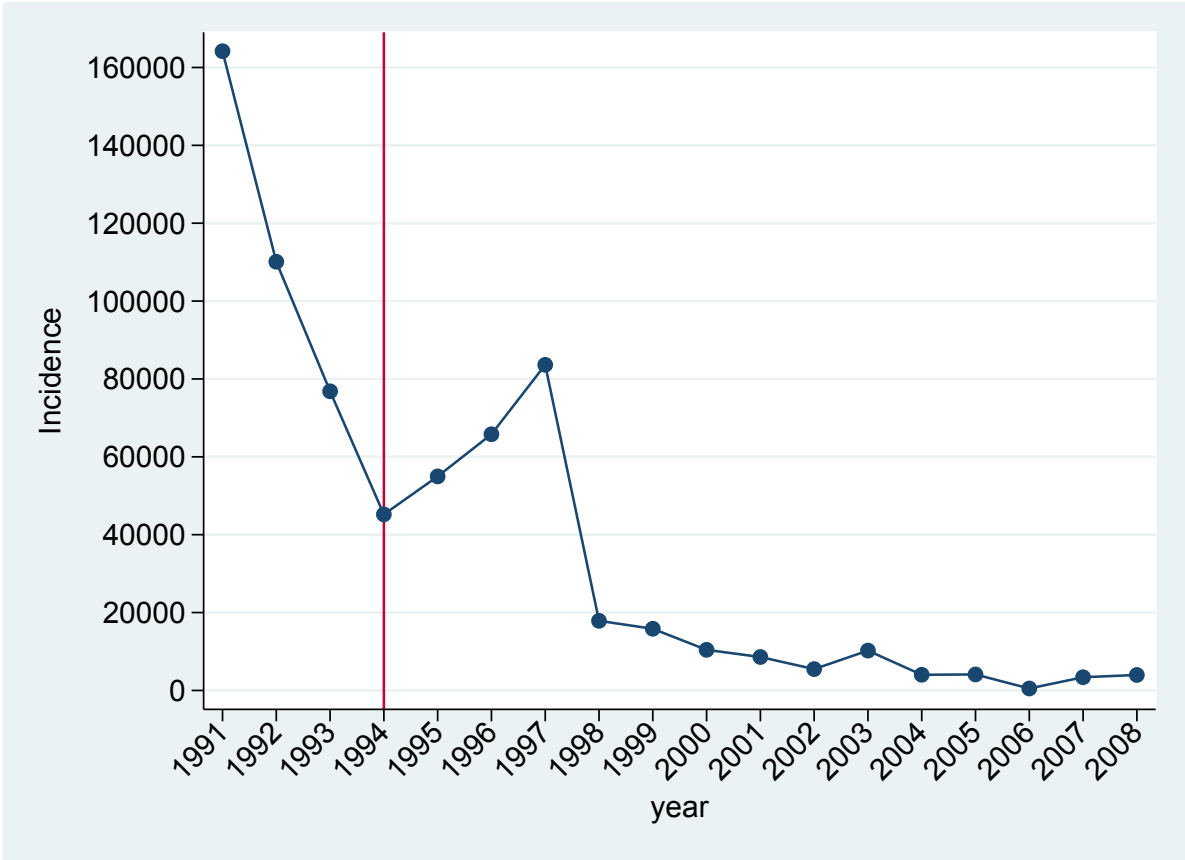

Figure A8: Evolution of measles incidence (*Réseau Sentinelles*)

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