

Dicing with Death: Do Speed Cameras Save Lives?

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Who am I?

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- **Other stuff**: Admissions, recruitment, consultancy, Schools...

Quick survey

- Who **likes** Maths at School?

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- Who thinks they are **good** at Maths?

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Quick survey

- Who **likes** Maths at School?
- Who thinks they are **good** at Maths?
- Who thinks Maths is **pointless**?
 - Algebra
 - Pythagoras
 - Data handling

Background

So many areas of Statistics are interested in what happens **on average**: Mean,

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- Road safety: accidents

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One area that is different is the field of **extreme value theory**.

Why might we be interested in **extremes**, rather than averages?

- Road safety: accidents
- Enviromental applications: flooding, hurricanes...

- Speed cameras
- Friend or foe?

Speed cameras: Friend or foe?



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Some headlines

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	Before	After	% change
Elwick Road	35	13	–63%
Nevinson Avenue	9	4	–56%

Hands-on I: Part A (*everyone*)

Hypothesis: Placing a piece of paper under a die causes it to decrease the number of sixes it rolls.

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- Take your die

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- Take your die
- Roll it twenty times and count the number of times you get a six!

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The experiment

- Take your die
- Roll it twenty times and count the number of times you get a six!
- To help, as you carry out this task, complete the tally chart you have been given

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The experiment

- Take your die
- Roll it twenty times and count the number of times you get a six!
- To help, as you carry out this task, complete the tally chart you have been given
- In a few minutes I will go round the room asking you to tell me your name and the number of sixes you have rolled

Hands-on I: Part B (*“high-scorers”*)

The two students with the most sixes should now roll their dice another 20 times

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The two students with the most sixes should now roll their dice another 20 times

- Again, count how many sixes you observe
- In a few minutes I'll ask you to give me your results

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- Complete the “before” and “after” table for the high-scorers

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Hands-on I: Part C (*everyone*)

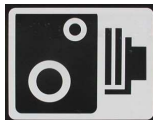
- Complete the “before” and “after” table for the high-scorers
- Calculate the **total percentage change**, i.e.

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- Do you believe the hypothesis?

Hands-on I: Part D (*discussion*)

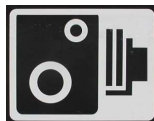
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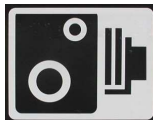


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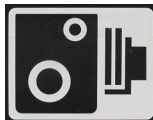


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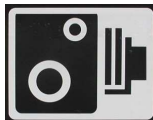


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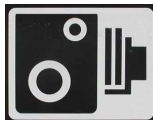


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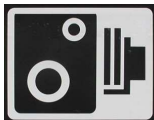


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If you don't believe the piece of paper caused the change in the number of sixes, why should we believe that speed cameras change the number of casualties?

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- “hotspots” have an abnormally high number of casualties
- In any “after” period, the number of casualties would probably come down anyway, even without a speed camera being installed!

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- Accident “hotspots” are chosen as speed camera sites
- “hotspots” have an abnormally high number of casualties
- In any “after” period, the number of casualties would probably come down anyway, even without a speed camera being installed!
- This is known as **Regression To (the) Mean**, or **RTM**

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	Before	RTM	After	% change	
				'The lie' ?	'The truth' ?
Elwick Road	35	23	13	-63%	-43%
Nevinson Avenue	9	6	4	-56%	-33%

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So how much of the quoted reduction is due to the speed cameras?

We can work this out statistically using the **Poisson distribution**.

	Before	RTM	After	% change	
				'The lie' ?	'The truth' ?
Elwick Road	35	23	13	-63%	-43%
Nevinson Avenue	9	6	4	-56%	-33%

What else could cause the number of casualties to come down anyway, even without a speed camera?

Regression To the Mean

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- Tall parents have tall children...
- ... but the children don't usually grow as tall as their parents!

Regression To the Mean

Another example

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Regression To the Mean

Another example

- Give a class of students a multiple choice exam in a subject they have no knowledge about
- The average score should be about 50%
- Take the top 5 students (whose mean score might be, say, 80%) and give them another multiple choice exam
- They'll probably do worse the second time around, and their mean score will "regress" toward 50%

Some accident data

The following data are the number of accidents, at a suspected road safety hotspot, each month over the last 5 years:

2	4	0	5	3	1	1	4	4	1	7	6
1	3	3	1	3	5	4	5	0	1	4	7
4	2	3	1	4	2	5	2	3	2	2	8
2	3	3	4	2	6	2	2	6	6	4	0
4	1	2	5	4	4	4	5	4	4	2	9

- 1 The local council will install a speed camera if there is evidence that the number accidents will exceed 5 next month. What should they do?
- 2 What is the probability of 10 accidents occurring next month?

Some accident data

Complete the following table:

x	$P(X = x)$	Poisson probability
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Some accident data

Data in ascending order:

0	0	0	1	1	1	1	1	1	1	1	2
2	2	2	2	2	2	2	2	2	2	2	3
3	3	3	3	3	3	3	4	4	4	4	4
4	4	4	4	4	4	4	4	4	4	5	5
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Therefore

$$P(X = 0) = \frac{3}{60} = 0.050$$

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Therefore

$$P(X = 0) = \frac{3}{60} = 0.050$$

$$P(X = 1) = \frac{8}{60} = 0.133$$

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1	0.133	
2		
3		
4		
5		
6		
7		
8		
9		
10		

Some accident data

Complete the following table:

x	$P(X = x)$	Poisson probability
0	0.050	
1	0.133	
2	0.200	
3	0.133	
4	0.250	
5	0.100	
6	0.067	
7	0.033	
8	0.017	
9	0.017	
10	0.000	

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$$P(X = x) = \frac{e^{-\lambda} \cdot \lambda^x}{x!},$$

where λ is the mean rate of occurrence

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In our example, we can work out

$$\lambda = \frac{0 + 0 + 0 + 1 + 1 + \dots + 8 + 9}{60} = 3.35 \text{ accidents.}$$

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In our example, we can work out

$$\lambda = \frac{0 + 0 + 0 + 1 + 1 + \dots + 8 + 9}{60} = 3.35 \text{ accidents.}$$

Therefore

$$P(X = 2) = \frac{e^{-3.35} \times 3.35^2}{2!} = 0.197$$

The Poisson distribution

Similarly,

$$P(X = 6) = \frac{e^{-3.35} \cdot 3.35^6}{6!} = 0.069$$

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$$P(X = 6) = \frac{e^{-3.35} \cdot 3.35^6}{6!} = 0.069$$

$$P(X = 7) = \frac{e^{-3.35} \cdot 3.35^7}{7!} = 0.033$$

The Poisson distribution

We can now update the table:

x	$P(X = x)$	Poisson probability
0	0.050	0.197
1	0.133	
2	0.200	
3	0.133	
4	0.250	
5	0.100	0.069
6	0.067	
7	0.033	0.033
8	0.017	
9	0.017	
10	0.000	

The Poisson distribution

We can now update the table:

x	$P(X = x)$	Poisson probability
0	0.050	0.035
1	0.133	0.118
2	0.200	0.197
3	0.133	0.220
4	0.250	0.184
5	0.100	0.123
6	0.067	0.069
7	0.033	0.033
8	0.017	0.014
9	0.017	0.005
10	0.000	0.002

The Poisson distribution

We can now update the table:

x	$P(X = x)$	Poisson probability
0	0.050	0.035
1	0.133	0.118
2	0.200	0.197
3	0.133	0.220
4	0.250	0.184
5	0.100	0.123
6	0.067	0.069
7	0.033	0.033
8	0.017	0.014
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10	0.000	0.002

The Poisson distribution

Going back to the original questions:

- 1 The local council will install a speed camera if there is evidence that the number accidents will exceed 5 next month. What should they do?
- 2 What is the probability of 10 accidents occurring next month?