



# Pedestrians' walking behavior and single accidents during winter conditions

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# Agenda

- Background for the research
- Methods in our study
- Results (walking speed, step length and step frequency)
- Results (Accidents)
- Discussion of the results

# Background



- The research is part of the Norwegian Public Roads Administrations' research program "BEVEGELSE" (Better operation and maintenance to get more people to walk and cycle more).
- Quantified relationships between winter operation and maintenance measures and walking behavior are lacking.
  - The typical studies found in the literature are comparisons between seasons (summer and winter).
  - Travel times, accident risks, costs of operations etc. can (perhaps should) be used to assess costs and benefits associated with different operation and maintenance regimes and practices.

# Research question

- What is the association between pavement surface conditions and walking speed, step length, step frequency and single accidents?



Start point

End point



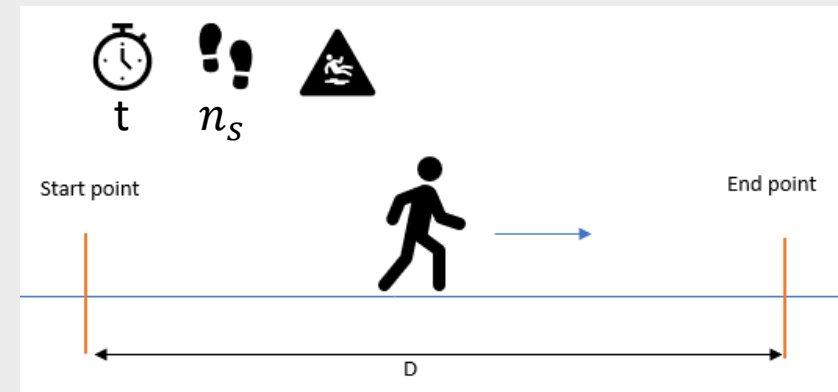
# Methods

We measured:

- Walking speed ( $V = \frac{D}{t}$  [m/s])
- Step frequency ( $f = \frac{n_s}{\frac{t}{60}}$  [steps/min])
- Step length ( $L_s = \frac{D}{n_s}$  [m])

- The relationship between these aspects of walking is:

$$V = f \times L_s$$



# Methods

- Observational study



Start point



End point

We registered the pedestrians:

- Age
  - Younger
  - Middle-aged
  - Older
- Sex
- Use of crampons

The data capture naturalistic walking behavior. The pedestrians were not aware of the study.

Registrations on weekdays between 07-09 and 15-17 (for the most part).

The data were collected in four different neighborhoods.

We also registered the air temperature and weather conditions.

# Accidents

- We also registered any observed single accidents and close-calls.
  - We defined a close-call as follows: The pedestrian is clearly slipping, losing balance and is about to fall but regains control of the situation and avoid falling.
  - If any pedestrian slipped and fell to the ground it was defined as a single accident.
    - The severity of the accidents were not possible to determine.



# Pavement surface conditions



Asphalt



Compact snow



Loose snow



Gritted ice

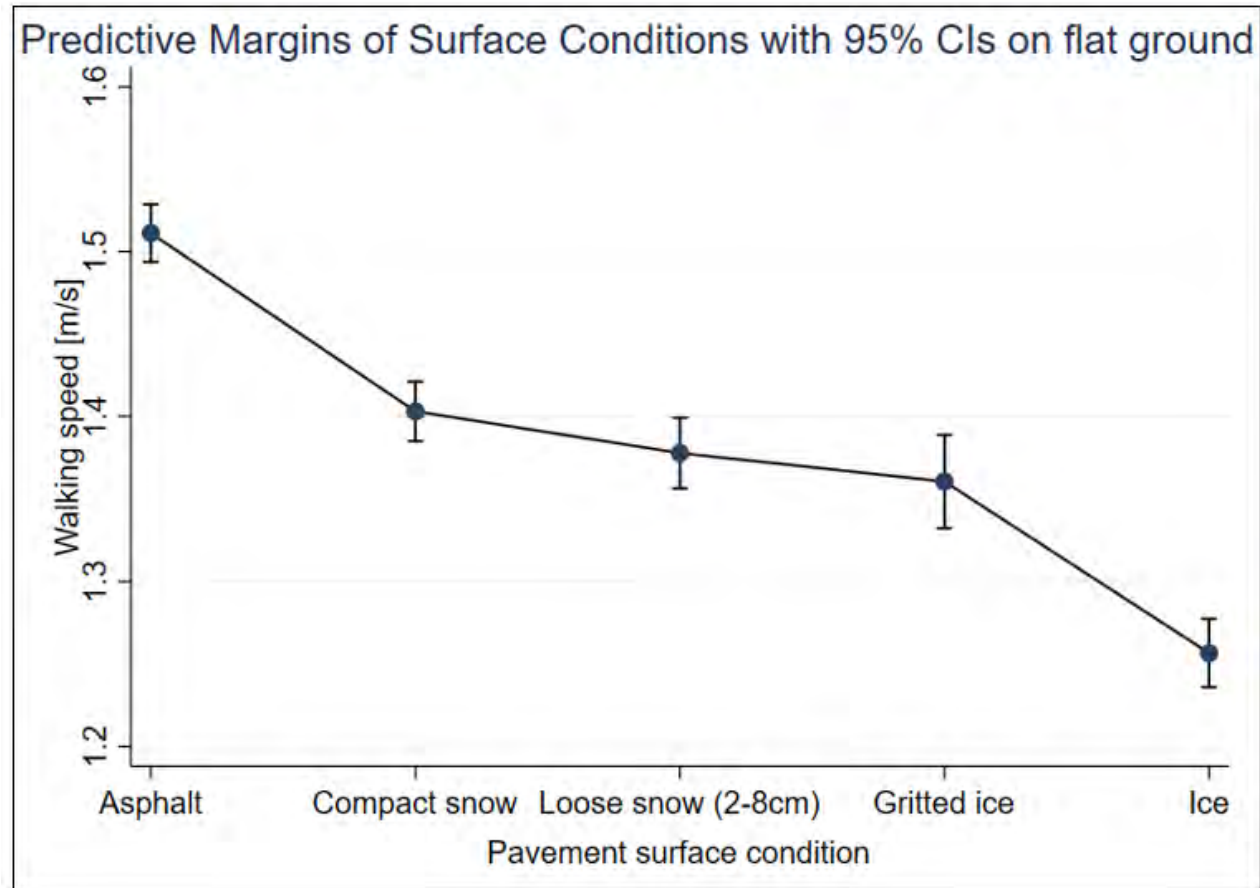


Ice



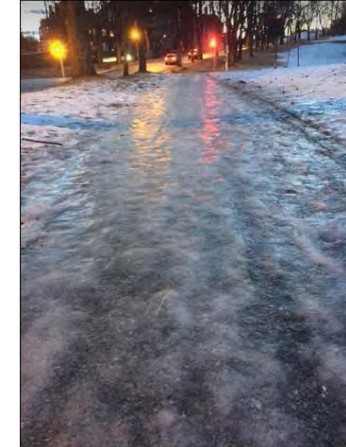
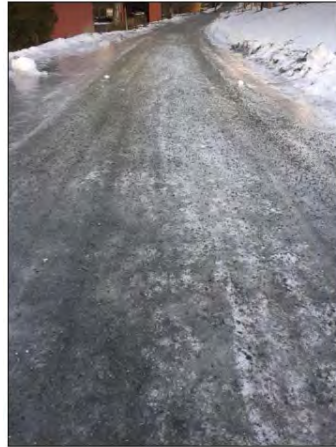
# Results (from OLS regression analyses)

Walking speed:

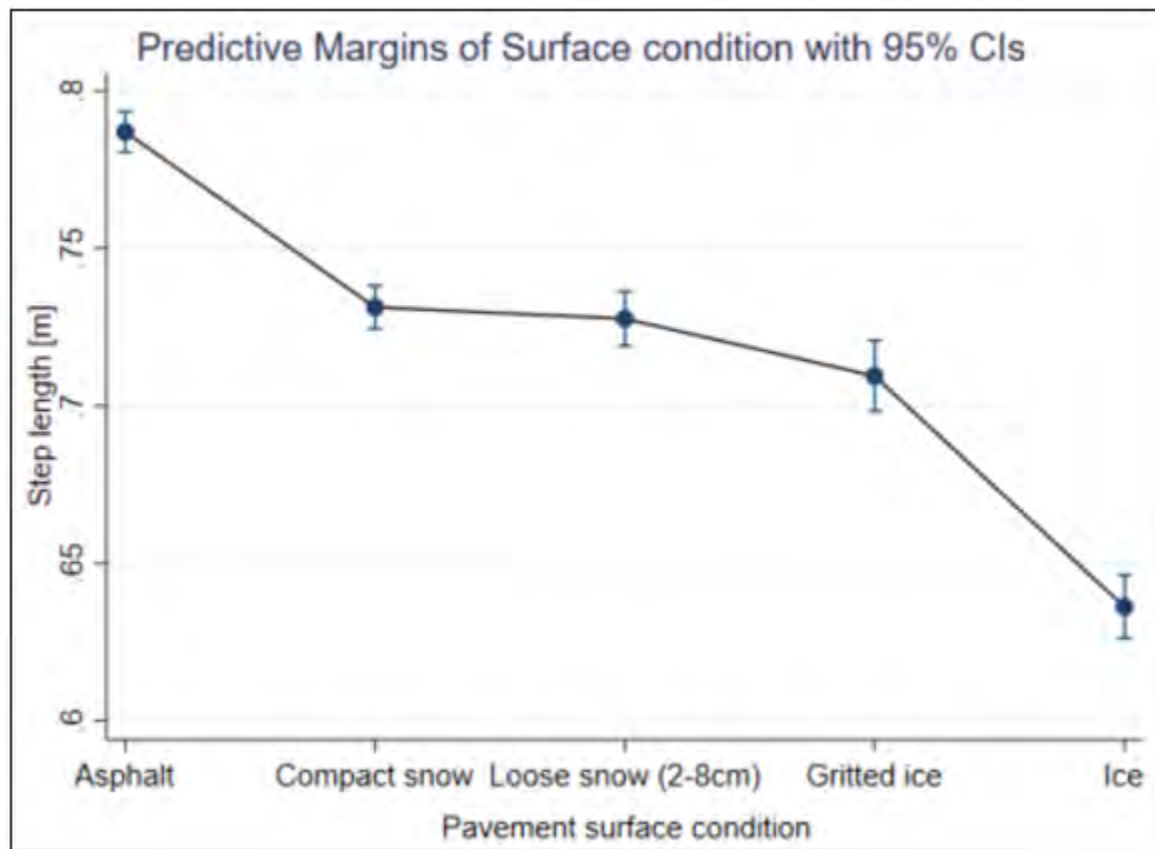


## Calculated travel times

- Pedestrians walk approximately 1 min/km slower on compact snow than on asphalt.
- Pedestrians walk approximately 1 min/km slower on clean ice than on gritted ice.
- Pedestrians walk approximately 2 min/km slower on clean ice than on asphalt.

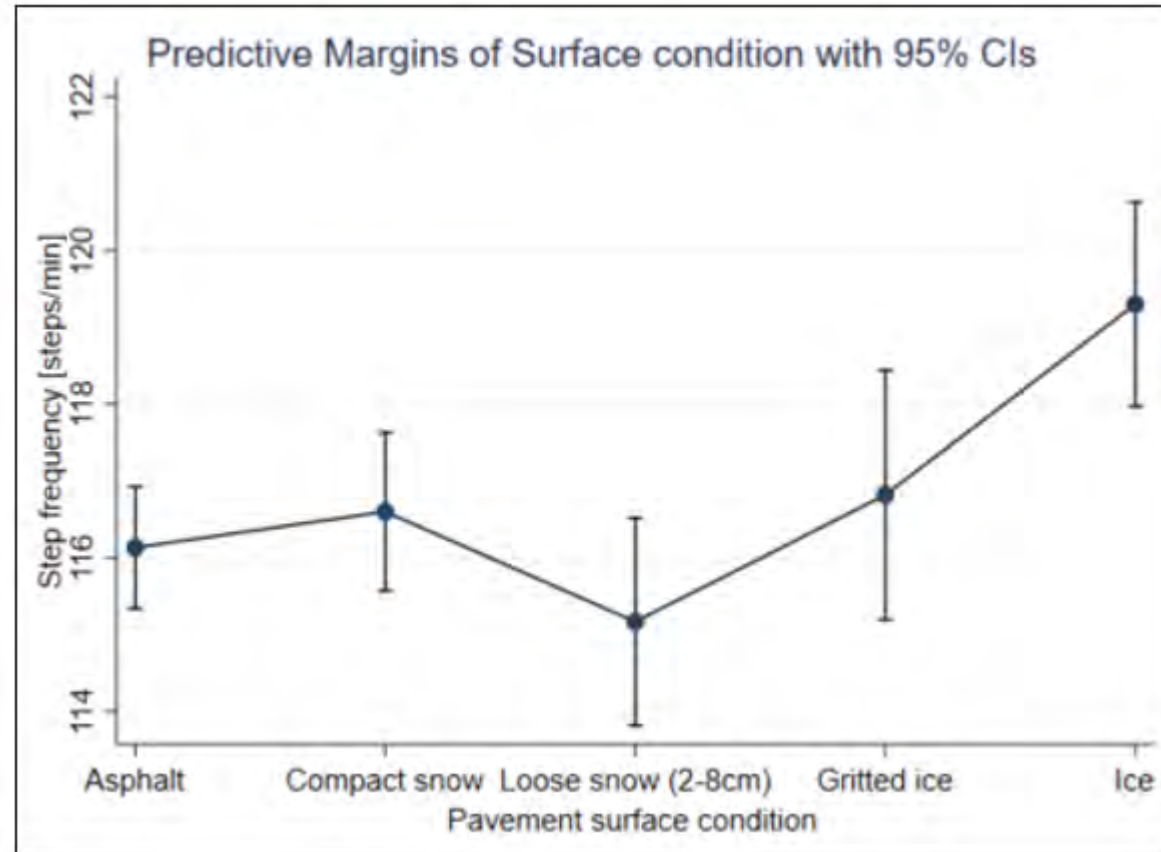


Step length:



Step frequency:

$$\frac{\text{Footprints}}{\text{Stopwatch}} = \frac{n_s}{t}$$



# Summary of the results

Pavement surface condition	Walking speed [m/s]	Step length [m]	Step frequency [steps/min] (Hz = steps/sec)
Asphalt	1.53	0.79	116 (1.94 Hz)
Compact snow	1.43	0.73	116 (1.94 Hz)
Loose snow	1.40	0.73	115 (1.92 Hz)
Gritted ice	1.38	0.71	117 (1.95 Hz)
Ice	1.27	0.64	119 (1.99 Hz)
N = 1 551			

# Accidents

NB! The observed single accidents did not necessarily occur between our defined start- and end-point where we measured the speed, step length, step frequency and where we registered the close calls.

Pavement surface condition	Number of no-incidents	Number of close calls	Number of close calls/all observations on the particular type of surface
Asphalt	662	0	0 %
Compact snow	682	3	0.44 %
Loose snow	314	0	0 %
Gritted ice	462	14	2.94 %
Ice	339	22	6.09 %
<b>Total</b>	<b>2 459</b>	<b>39</b>	<b>1.56 %</b>

Pavement surface condition	Single accidents
Asphalt	0
Compact snow	8
Loose snow	1
Gritted ice	2
Ice	0



# The one common feature between all the observed single accidents:

- They did all occur on particularly slippery spots surrounded by seemingly non-slippery conditions!



4 of the single accidents happened at this exact spot within 1.5 hours of observations.

Within the same time period 3 of the single accidents happened at a similar spot on the opposite side of the road.



The day after. The pavement had been gritted and we observed no accidents within a 2-hour time period.

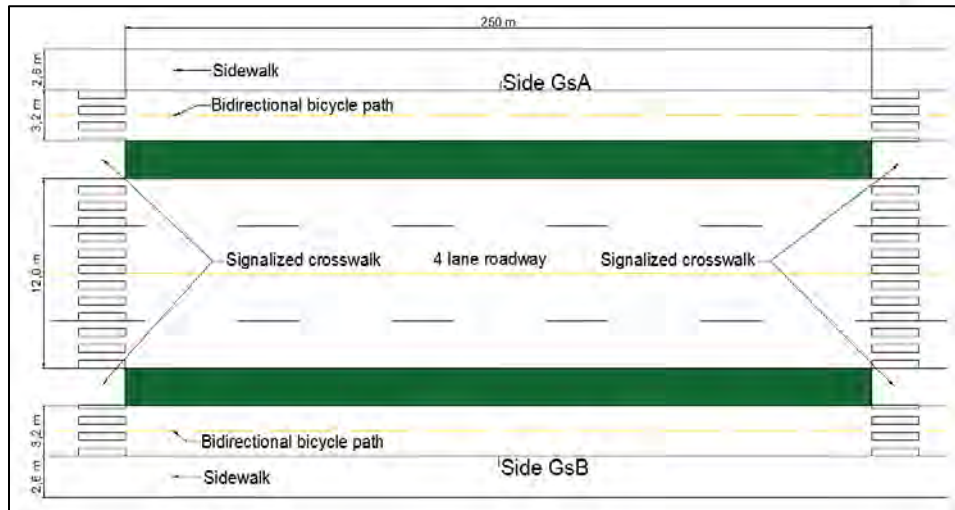
- Lessons learned:

- Pedestrians walk cautiously on known slippery surfaces. They adapt to the conditions and walk accordingly (they walk slower and with shorter steps -> indicating a “cautious gait pattern”).
  - But typically, less so on surfaces where we observed most of the actual single accidents.
    - The results indicate that “black spots” are likely to cause a substantial amount of single accidents and that the effect of “surprise” is important.
    - This might affect whether observational studies of close calls can be used to infer single accident risks on various pavement surface conditions.
    - However, the sample size (number of close calls and single accidents) is relatively small ... so we believe more data is necessary.

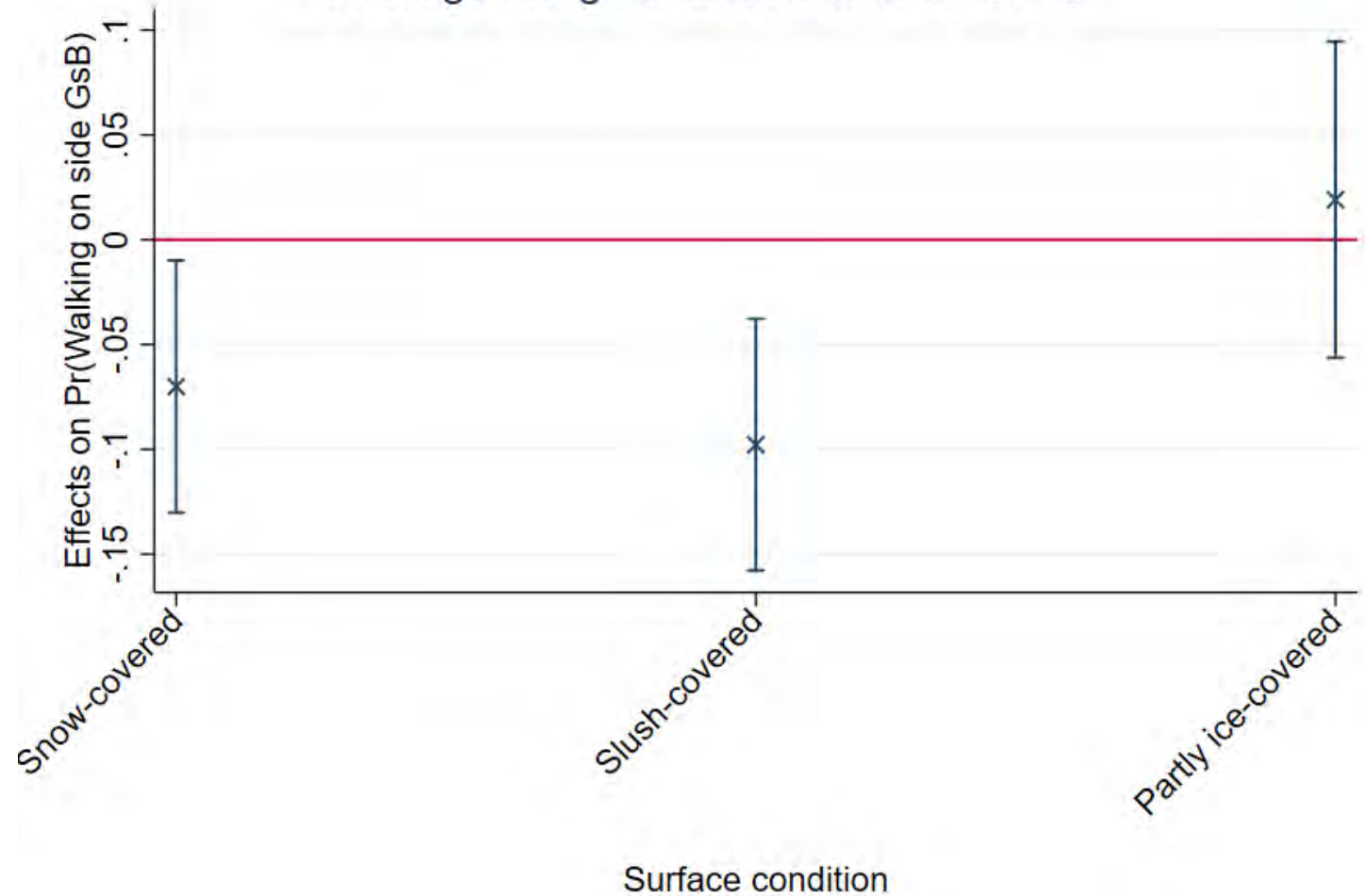


# Pedestrians' route choice

- The cautious walking behavior was, to some degree, also found in a previous study we conducted on pedestrians' route choice



Average Marginal Effects with 95% CIs



# Thank you for your attention!

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Q&A