Cloudy with a Chance of Pain:
A Smartphone-based Study of Weather, Disease Severity and Physical Activity in Patients with Rheumatoid Arthritis

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@CloudyPain
Smedslund and Hagen (2011): “Does rain really cause pain? A systematic review of the associations between weather factors and severity of pain in people with rheumatoid arthritis”

9 studies

Temperature, pressure, wind, humidity (4 measures), sunshine, cloud cover, thunderstorms, precipitation, North-Atlantic Oscillation Index, solar radio flux, sunspot count, ultraviolet radiation.
1. No consistent group effect of weather conditions on pain for people with rheumatoid arthritis.

2. Some patients may be more sensitive to weather-induced pain changes than others.
What limits previous studies?

**Small sample sizes**

- 16–92 patients
- 2 weeks to one year
  (most less than a month)
What limits previous studies?

Not exposed to full-range of weather conditions

Patients were not exposed to outside weather conditions

Sample unrepresentative of average rheumatoid arthritis patient
What limits previous studies?

How weather data was handled

• Correlations, not causations
• Limited range of weather variables: absolute values, change, threshold, lag effect
• Weather/climate data not coincident with patient
What limits previous studies?

Lack of physical linkage between weather and pain
Disease severity (app) + Weather (GPS)

Largest and longest data collection effort ever
Association between weather and pain
Pain forecast

mobile Health (mHealth)
Pilot study, 2015

Co-design app with patients with rheumatoid arthritis

Interviews with patients to understand motivators and barriers to regular data entry

Pilot study of daily data entry over 2 months
**Arthritis-specific items**
1. Pain severity
2. Fatigue
3. Tiredness on waking
4. Morning stiffness
5. Wellbeing
6. Overall disease severity

**Non arthritis-specific items**
7. Mood
8. Physical activity
9. Time spent outside
10. Perceived influence of weather

How severe was your fatigue today?: Moderate fatigue
Pilot study

Recruited 20 patients with rheumatoid arthritis

6 participants dropped out
  Capture app problems (battery life, technical issues) \( (n = 4) \)
  Health issues \( (n = 2) \)

Overall completion rate while in study: 68%
>5 entries per week 65% of the time
During the pilot study...
Can I avoid, or treat, arthritis?

Chris’ simple arthritis exercises, and join in the big arthritis & weather experiment

- Sign up to take part in the study
  (www.cloudywithachanceofpain.com)
Cumulative enrolment in 1st week

BBC Trust me I'm a Doctor

BBC 'Breakfast'
12,000+ patients last month
Data collection is still ongoing…

But we have a few preliminary results about the data we’re collecting that may help others doing mHealth (mobile Health) studies.
Four clusters of participant engagement

Over a 143–183-day period:

- 14% averaged 175 days data entry → high engagement
- 22% averaged 88 days data entry → moderate engagement
- 39% averaged 8 days data entry → low engagement
- 25% averaged 1 day data entry → tourists

Duce et al. (2017, in preparation)
Type of phone determines frequency of location reporting.

**Geolocations retrieved per participant/day by operating system**

Operating system: [Android](#) [iOS](#)

Beukenhorst et al. (2016, submitted)
You can help answer a 2300 year old question

Many people have wondered about how the weather affects health

This goes back as far as Hippocrates, the father of modern medicine who

Why do you need me to take part?

We need to collect data from lots of people throughout 2016 to create a big database. We can only uncover the relationship between weather and pain if we have data from a very large number of people.