Component 4: Quantitative studies of health impacts, work capacity and prevention

For this whole section I think it is important to try to establish the importance of humidity on heat stress. Humidity I think) is under-rated by both employees and employers Can I suggest 3 situations: Hot and dry, warm and humid (monsoon season if it exists) and cooler part of year.

The Hothaps pilot study and the qualitative study will have identified occupations in the location that are particularly vulnerable to heat-induced health effects and work capacity reduction. The target groups in the quantitative study are occupational groups with high heat exposure during at least part of the year (the hot season) and the same groups will then be studied for comparison during a cooler (not so hot) part of the year doing the same type of work. The same group of workers may not be available during other parts of the year because of the large turnover (seasonal workers). They could use a random sample in both cases if they cannot use the same workers.

10.1 Aims

The aims of this Hothaps study component are:

- To measure and quantify the impact of high heat exposure on work output per hour in occupations vulnerable to heat exposure
- To assess effects of heat exposure on health and, if possible, on physiological measurements .
- To record the preventive interventions that are currently used to reduce the impacts in the occupational groups studied and, if possible, assess their effectiveness
- To test the preventive impact of potential new interventions

10.2 Study design, study groups:

The study uses a longitudinal cohort ("case-crossover" or "panel study") design including defined groups of workers with high heat exposure at work, who will be studied at least twice. Work output should be quantifiable in terms of production output per working hour, number of working hours per day, identifying the periods over 24-hours when work is carried out. For each worker the reported health status and work output (per working hour) during hot and not so hot periods of work (or seasons of the year) are compared. The case-crossover study design (Checkoway, 2004) incorporates analysis to assess variations of health variables and work output in relation to daily heat exposure during hot and less hot seasons.

Potential target groups are adults in occupations vulnerable to heat exposure:

- work outdoors in hot sunlight,
- work with production processes that create or use heat (e.g. glass factories),
- work that requires high physical activity input,
- indoor factory and office workers without air conditioning in hot places.
- Office workers required to wear suits, workers required to wear protective clothing

It is assumed that each group studied should include at least 20 workers whose work activities are similar during both hot and less hot work periods or seasons and whose work output can be quantified. Smaller group numbers might be sufficient if the heat effects are substantial. A statistical power calculation method to define study population size requirement is currently being developed by the Hothaps team.

Two approaches: a) panel study using self-completed diaries

b) observational study using variables measured by researchers.

10.3 Data required

The following data needs to be collected:

1. Climate outdoors at the location

Outdoor hourly air temperature, humidity (any measure: absolute humidity, dew point or relative humidity), wind-speed and solar radiation (if available) at the workplace. It may be possible to collect these data from routine meteorological stations in the locality. Wind speed can be estimated from the Beaufort scale (see appendix xx). Longitudinal data on air temperature and relative humidity can be measured with a "USB data-logger" at half hourly time intervals (this equipment can record at much shorter intervals to give very detailed heat exposure data) (see Component 2).

2. Climate variables at the workplace
    a. Indoor climate variables in the workplace (hourly temperature and humidity).
    b. Specific measurements of the formal components of WBGT using specialised equipment or calculated values from mathematical formulas based on more basic recordings with a data logger.
    c. Estimate of the wind speed (including wind from fans etc)
3. Description of the type of work carried out
4. Daily work schedule including start and finish times of work on each day, and the length of breaks (if available), as well as the common means of travel to work and travel time.
5. Recorded or self-reported health effects of heat, such as heat exhaustion (with need for a break), excessive sweating, slight or serious health stroke, or other symptoms such as fainting at work, not thinking clearly, vomiting, needing to do home etc.
6. Daily work output

    Quantification of daily work output by individual workers (e.g length of brick wall built; number of shirts sewn; meters of sugar cane row cut). These data may in some workplaces be collected from existing records in the workplace.

    An alternative to specific work output data could be measurements of individual physical activity (PA) patterns using an "accelerometer". A comparison of PA during the hottest hours and during cooler hours can for some jobs be quantified into heat effects on productivity (methods studies of this approach are in progress).

7. Additional data (if possible):
    a. Physiological measures (body temperature and heart rate at start, middle and end of workday)
    b. Hydration indicators (e.g. body weight loss during work shift, daily intake of liquid, , urine colour comparing to standard urine colour chart, urinary creatinine or specific gravity)
    c. Psychological measures (heart rate, sweat rate and fatigue level measured with standardised questionnaire)

Table 4 shows the minimum and ideal data to be collected.

10.4 Data collection

Data according to the description above is collected during consecutive days in each of two study periods including, ideally, at least 10 hot working days and 10 cooler days (the difference between work period temperatures should be 10 degrees or more, if possible) (periods with intermediate heat exposure can be

included to create a more continuous exposure range). Detailed methods will depend on local conditions, but the methods need to be clearly explained in the report.

A proposed data collection form is presented in Table 5. The data can be collected via interviews at the end of each day or via "diaries" that workers keep and fill in at the end of each day.

Table 4. Minimum and ideal additional data collected in quantitative Hothaps study

Type of data and variables	Minimum data	Ideal additional data
Heat exposure	1. Air temperature in work area during hottest hour and coolest hour 2. Absolute humidity (e.g. dew point) in work area at the same time as air temperature measurements 3. Description of climate conditions (solar radiation, radiated heat exposure from processes or equipment, breeze)	In work area for each hour: air temperature, absolute humidity, natural wet bulb temperature, globe temperature, wind-speed. WBGT measurement.
Work type	Short description of work, how it is carried out and how output can be quantified	More detailed description of work, how it is carried out and how output can be quantified
Daily work output and hours	Time when work started and finished, duration of work, output in the same period (calculate output per hour)	Timing and length of breaks, exact measurement of what the worker does at different times. Accelerometer measurements of physical activity may be tested
Preventive measures	Brief description of methods used to reduce heat exposure at work, re-hydration procedures (liquid intake during work day) and any methods employed for cooling down	Detailed description of methods used, timing, volume and provision of re-hydration, etc.; liquid intake during shift
Symptoms of heat exposure	The workers own history of how the work environment feels during heat exposure; any symptoms from heat strain	More detailed information about symptoms or clinical signs, and when they happened; past incidence data based on stored records.
Physiological reaction to heat	Nil	Pulse rate at different times during shift; core body temperature (tympanic, oral or rectal) just before end of shift; Level of heat shock protein in blood; indicators of dehydration (e.g. urinary specific gravity or creatinine, net body weight loss taking liquid intake into account)
Other physical activity during the day	Description of daily commuting to/from work (walk, bicyle, bus, car, etc.)	More details about heat exposure during travel to work, daily physical labour at home (e.g. family farm work); exercise activities.

10.5 Data analysis and reporting

The heat exposure, occurrence of symptoms, drink consumption and work output per hour of each worker in the hot and colder (humid?) seasons is compared. During each season daily variations in work output in relation to heat is analysed. If a number of data points at different heat exposures are available for the same worker, it will be possible to create a exposure-response relationship for heat impact on health and work output.

If heat effects on work capacity are seen, the physiological measurements (if available) can be used to further explain the mechanisms behind the findings. For workers using different cooling or rehydration methods, comparisons between different days or seasons or groups of workers can be used to assess the impact of the preventive interventions. The exact analysis methods will depend on the local dataset, and the design of comparison methods. It is important to include statistical advice both at the study design stage and the analysis stage. Differences between individuals doing the same work in a location will be noted. With a sufficient number of field observations the individual variability of heat exposure and effects can be described with statistical methods.

Table 5. Hothaps quantitative field study data recording form

(one page for each day of study for each worker)

Worker Name: _____ Study ID number: _____

Job description: _____ Study date: _____

Work indoors or outdoors	Work started	Work finished	Length of breaks during work period	Cooling actions	Production output	Weather data (next table)	Other data available?

Items to include: Cooling actions: shade, fan, air-con, rehydration, other (what?) _____

Other data: heart rate, core body temperature, urinary colour , etc.

Hourly climate exposure data, drink consumption and health effects data (ideal data, less if impossible to collect data hourly, datalogger equipment might be best):

Outdoors next to worksite: air temperature (Ta-o), relative humidity (RH-o) (or other humidity measure, such as dew point, Td-o). Can be measured with a *Data-logger*. Wind speed (v-o), solar radiation (SR-o) This coding is confusing because we tend to use "o" for outdoors and "i" for indoors. In the following sentence you use "i" for outdoors or indoors. Maybe Ta-v etc to represent in the vicinity of the work site.

At worksite (indoors or outdoors): air temperature (Ta-i), humidity (RH-i or Td-i), natural wet bulb temperature (Tnwb-i), globe temperature (Tg-i), WBGT

Time	Outdoors, next to workplace					At workplace (indoors or outdoors?)					Drinks, l/ hour Symptoms *	Production output
	Ta-o	RH-o	Td-o	V-o	SR-o	Ta-i	RH-i	Tnwb-i	Tg-i	WBGT		
06-07												
07-08												
08-09												
09-10												
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* a list of codes for different symptoms and signs needs to be developed for each situation; it should include headache, nausea, exhaustion, dizziness, etc.