White Paper

Cost Savings Calculator

Personal Protective Equipment

Caco America LLC

Boosting productivity with advanced cooling solutions

Abstract

Reducing heat stress offers significant benefits, including enhanced business profitability. Beyond being a health obligation, mitigating heat stress directly boosts productivity, creating a more efficient and effective work environment. As a result, workers experiencing less heat stress will be more productive than workers without the correct gear. Since Caco America's GE PPE Helmets are specifically engineered to fight heat stress, the company has quantified the productivity difference between its helmets and EPS foam helmets with an interactive calculator. In an ideal modeled scenario where the microclimate around the head is set at 69.5°F with 50% relative humidity, a worker with a GH401 helmet is about 5.91% more productive than a worker with a traditional EPS helmet.

Introduction

Experts widely recognize that rising temperatures directly impact worker performance. The University of Chicago's findings highlight that productivity can drop by 4% for every degree over 80°F, especially in labor-intensive environments [1]. Research shows that at 86°F with 45% relative humidity, productivity drops by 15% [2]. At 95°F and 75% humidity, the loss increases to 50%, with a heightened risk of heat-related injuries [3]. As temperatures rise, natural defense mechanisms, such as taking longer breaks or reducing activity levels, further impact output.

Caco America's GE Line of Safety Helmets offers a compelling solution. With temperatures inside the helmet kept up to 10.92°F cooler than EPS foam ones, these helmets help combat the loss of productivity caused by extreme heat[1] [4]. Hence, anyone using Caco America's helmets should be more efficient, so less money will be lost in unworked compensation.

Heat Stress ⟶ Productivity ⟶ Profitability

Figure 1: Diagram of variable relationship. Heat stress affects productivity, and productivity affects profitability. Hence, heat stress affects profitability.

In other words, **Caco America's helmets are more cost-effective because they reduce a company's financial loss. This additional amount of money retained is computed with Caco America's one-of-a-kind interactive calculator, which can be adapted to each client. This whitepaper unpacks its use and results.**

GE helmets are a better choice if minimizing losses is a priority. They ensure higher productivity levels, safer working conditions, and better financial outcomes by protecting workers from overheating. They are more than safety gear; they're strategic investments in productivity and profitability.

Start With the Ideal, Then Get Real

The Cost Savings Calculator provides directions into the effects of heat stress on a business's profitability, for it is based on a simulated experiment. Based on the ideal temperature conditions and studies, the calculator demonstrates that cooler helmets are a worthy investment: they decrease losses on productivity.

The ideal and real helmet scenarios have the main puzzle piece in common: they use the GE cooling helmets. Also, the heat index inside a human head behaves very similar to the replica head in the simulation. The helmets in the Koroyd study were put on a head form with a semipermeable membrane passable only by water vapor—simulating human thermoregulation and mimicking human skin.

Moreover, the study does not consider the head heat index between 0 and 15 minutes of putting on the helmet because the heat index rapidly varies within that period, so significant comparisons can't be made.

Nonetheless, even though it yields savings predictions based on different productivity studies, the reader must keep in mind that, by definition, an ideal case study is not reality. The used studies do not account for:

- Additional conditions (e.g., solar radiation and clothing) require further testing, since the heat index measure does not take it into account. Thus, the solar radiation and how much the helmet isolates from solar radiation is not measured in this study. Nonetheless, the isolation is mainly done by the helmet shell and probably depends on the shell color.

[1]For the GE GH401 helmet at an initial temperature of 69.8° F and a relative humidity of 50%.

- The tests on the Koroyd study were performed on class E helmets (unvented helmets) limiting the influence of the environmental conditions.
- The heat index inside the helmet is unequal to the overall environment—it is a representation of the microclimate around the head. It is also unequal to the average full-body heat index.
- The heat index varies depending on the pursued physical activity. The Koroyd study states that after about 15 minutes the heat index inside the helmet reaches a constant value, yet in real life that value could change depending on the user's movement.

These limitations should not be negatively seen; on the contrary, despite them factual relations can be inferred with research papers. They are areas of potential study, and further studies can even offer additional heat stress reduction benefits. For instance,

- Market GE helmets (GH400 and GH500) are vented, so workers should perceive an even lower heat index than the one from the study.
- It is possible that at higher initial temperatures the helmet wicks away more heat.

For more information regarding the Koroyd study and heat index in GE helmets, please read "Heat-Reducing Workplace Helmets," Caco America's first white paper.

Parameters

These are the variables provided by the client; these are the inputs to the calculator functions, and the field seen on the left of the calculator. They are divided into two main categories—Climate Parameters and Client Business Parameters—and are self-explanatory.

Climate Parameters:

- Temperature [°F] (64°F to 74°F)
- Relative Humidity [%]

Client Business Parameters:

- Wages per worker per hour
- Hours worked per day
- Days worked per week
- Total number of construction workers

It is important to keep in mind that both types of parameters need to be correspondent to one another. For instance, if the temperature is at 70°F and the relative humidity is at 60%, then the hours worked per day is the number of hours in which the temperature is relatively close to those climate parameters—not the full working day—since temperature and relative humidity inversely vary throughout the day.

Since the calculator uniquely focuses on showing how Caco America's helmets are much better than the EPS foam helmets in a very specific ideal scenario, the climate parameters must stay close to 69.5 °F and 50% relative humidity (note: this automatically affects the heat index seen in the next section).

Results

These are the outputs of formulas fed with the parameters. The results are divided into two main categories: Scientific and Monetary.

Scientific Results:

- Heat Index [°F].

  This is the initial perceived temperature in the body, which is different from the room temperature. The heat index (HI) measures how much thermal discomfort is created by the PPE; in that scenario it is considered that the ideal scenario is when the user does not feel any difference while wearing a helmet (the goal being to avoid the removal of the PPE). The HI is an indicator of heat stress,[2] so other external factors—like humidity—play an important role in how human thermoregulation keeps the body cool.

  There are many other heat stress indicators, yet this one depends on the room temperature and the relative humidity—two parameters from the calculator. This specific computation comes from a multiple regression analysis crafted by Lans P. Rothfusz [5]. More details on this calculation can be found on the National Weather Service website: https://www.wpc.ncep.noaa.gov/html/heatindex_equation.shtml.

[2] Heat stress is the physiological stress experienced due to excessive heat when the body can't regulate its internal temperature properly.

- Head Heat Index After 15 Minutes [°F].

This variable describes the same concept as the previous one, however this one is the approximate heat index in the head after using the helmet for more than 15 minutes. Research shows that after 15 minutes the heat index plateaued, which makes sense since the head gets warmer as there is restricted air flow [6].

The Head Heat Index is an estimate of the initial Heat Index average increase from the Koroyd study (with an initial room temperature of 69.8 °F and relative humidity of 50%), as shown in Table 1. Nonetheless, limiting the (room) Temperature parameter range to +/-5°F does not significantly affect the HI final variation within the GE helmet, for it allows for continuous airflow [7].

Type I		Type II	
GE GH401	EPS Foam	GE GH501	EPS Foam
+16.38°F	+27.31°F	+19.26°F	+27.38°F

Table 1: Average increase in head HI after wearing a helmet for over 15 minutes.

- Worker Capacity [%].

Heat stress decreases capacity—mental and physical—for work, for the body has an urgent necessity to regulate its temperature causing fatigue without the correct heat stress mitigation. As previously mentioned, this incurs the employers in two types of work:

1. Lost work time for breaks
2. Lost productivity

Foster et al. created a function that predicts a worker's productivity based on his or her HI [8]. This means that a worker with a high HI will be very unproductive, perhaps reaching levels of 0% work capacity.[3] The formula for the model is provided in the next column, where the heat index is in degree Celsius, and it was the highest performing model among the various heat stress descriptors.

$$\textbf{Worker Capacity} = \frac{100}{1 + \left(\frac{55.37}{\textbf{heat index}}\right)^{-2.90}}$$

For instance, a worker capacity of 90% means that the worker is 90% percent productive in its working time.

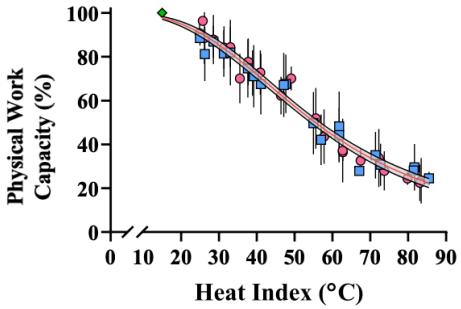

Figure 1: Model for the reduction of physical work capacity during heat stress, extracted from Foster et al.

Using data from Table 1, and setting the microclimate around the head at 69.5°F with 50% relative humidity, the model yields that a worker with a GH401 helmet has a worker capacity of about 84.41%, while one with a traditional EPS helmet has a worker capacity of 78.50%. Hence, a GH401 user is about 5.91% more productive than a worker with a traditional EPS helmet—based on the heat-productivity study.

Monetary Results:

- Money lost per worker per hour.

This is the lost productivity cost, or the portion of wages paid for unproductive time. For a worker earning $50/hour and being 50% productive, this means losing $100 in wages and benefits in just 4 hours of high heat conditions while sacrificing two hours of effective productivity. In other words, $25 is the worker's unproductive time. Over several days, this compounds into significant financial losses.

[3] Foster et al. show that a heat index of 58°F (or room temperature of 59°F and relative humidity of 65%) is the optimal environment for full productivity.

- Money difference per hour per worker.

  It is the difference in lost productivity costs. Since the GE helmets are cooler than EPS foam helmets, they also cause workers to be more productive, so Caco America's helmets "cost less" to employers than using other helmets.

- Money difference per day per worker.

  For this variable the "money difference per hour per worker" is multiplied by that amount of worked hours per day relatively at the same HI.

- Money difference per year per worker.

  Same as the previous variable, but times the days worked per week and the number of weeks in a year.

- Total investment.

  Total investment is the number of workers times the cost of the GE helmet.

- Saves in losses per year.

  This equals "Money difference per year per worker" multiplied by the number of workers.

Next Steps

This paper represents thought leadership in the helmet-heat field. By taking important pieces from various research studies Caco America formed a thorough productivity paper. Caco America is committed to research and breaking discovery barrier: this white paper represents that first step into a field filled with untapped potential.

Some of Caco America's desired next steps include:

- Replicating the Koroyd study with different initial microchamber parameters
- Developing a model that represents the complete time versus head heat index relationship of a GE helmet and an EPS foam helmet

Contact

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