

# Girl Pulled Alive from Ruins, 15 Days after Earthquake

by

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## Part I – The Facts of the Case

I read the headlines, almost unbelieving. From all that disaster in Port-au-Prince, Haiti, in January 2010, a miracle occurred; someone was still alive, more than two weeks after the buildings collapsed around her. The paper reported that Darlene Etienne, a 17-year-old university student, was found in the rubble of a home near the university, very dehydrated, groaning weakly, but still conscious, with a very weak pulse and low blood pressure. Rescuers gave her oxygen and water and immediately evacuated her to a French military hospital ship for treatment.

“She was definitely within hours or perhaps minutes of death,” said one rescuer. “It’s exceptional that she managed to survive this long,” said another. “In fact, it is rare for anyone to survive more than 72 hours without water, and no survivors have been documented in any earthquake after 14 days.”

How did Darlene manage to survive? Was it due to her ability to conserve her body water, or did she somehow gain access to a meager supply of water while still buried?

### Questions

1. What are the physical signs and symptoms of progressive dehydration, such as Darlene might have experienced?
2. What do we know so far about Darlene’s physiological responses to her prolonged ordeal?

### References

Refer to the following website for information about dehydration:

Signs and Symptoms of Dehydration

<http://www.symptomsofdehydration.com/>

The site includes physiological characteristics associated with progressive states of dehydration.

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*Image credit:* “Haitian women sit on rubble from a collapsed building in Port-au-Prince, Haiti, January 20, 2010. U.S. and international military units and civilian aid agencies are conducting humanitarian and disaster relief operations as part of Operation Unified Response after a 7.0-magnitude earthquake caused severe damage near Port-au-Prince Jan. 12, 2010. (DoD photo by Master Sgt. Jeremy Lock, U.S. Air Force/Released). VIRIN: 100121-F-1644L-018.” <http://www.defenseimagery.mil/imagery.html#guid=e6810a76b342d95e1c9a6abf449ffcc3b352ba44>.

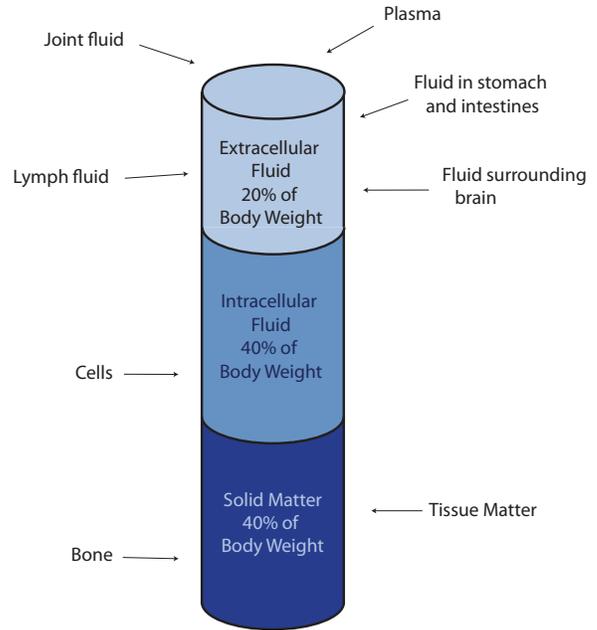
## Part II – Calculating Darlene’s Water Balance

The physiological consequences of Darlene’s entrapment in the earthquake rubble were dehydration, starvation, and potentially heat exposure from daytime temperatures near 35°C (95°F) and high humidity. However, let’s look first at just her ability to survive the dehydration of being buried for 15 days.

First, we should consider where water is “stored” in the body that could be tapped during Darlene’s prolonged entrapment.

### Questions

3. Based on the diagram to the right, list the major water compartments of the body, and explain how water moves between them. What is the 60-40-20 rule for body water?
  4. Assuming that Darlene did NOT have access to water during her entrapment, how would her body begin to lose water? What are the specific avenues of water loss?
  5. How might the body immediately begin to reduce those avenues of water loss in Question #4? What important physiological reflexes would minimize the rate of water loss from those specific avenues?
  6. How would changes in blood flow to specific organs help Darlene resist dehydration? Consider how reduction of function in particular organ systems might help conserve water.
  7. Calculation of Darlene’s water loss—Enter answers in the spaces and table below as directed.
    - a. Let’s assume that Darlene weighs about 55 kg (~120 lb). Based on the 60-40-20 rule, how much total body water (in liters) does Darlene have? Record your answer below.
    - b. Most humans can withstand only a 12% loss of total body water before they progress to clinical shock. The lethal body water loss for humans is 20% of total body water. Based on these estimates, how many liters of body water can Darlene afford to lose? Record your answer below.
    - c. Data from published studies on women show that water loss varies as a function of age, weight, and environment. Values range from 2.7 L/day for young female adults (Sawha et al., 2005) to 3.3 L/day in active (but not exercising), young female students (Westerterp et al., 2010). How many days without water could Darlene survive at this rate of dehydration, assuming a maximum of 12% body water loss? Record your answer in the table below.
    - d. Are these water loss values (in 7c) of any use in predicting how much water Darlene might have lost per day? Justify your answer.
    - e. The absolute bare minimum water loss possible for humans, with all compensating mechanisms in force, is about 1.2–1.4 L/day (approximately 6 cups of liquid). How many days could Darlene survive at this rate of water loss? Record your answer in the table below.
    - f. At the absolute minimal rate of water loss (7e) and maximal tolerance of dehydration (20% of total body water from 7b), how many days without water could Darlene survive? Record your answer in the table below.
    - g. Now, based on these calculations, could Darlene have survived 15 days without water? Explain the basis for your answer.
- 7a. Total body water in liters (55 kg human) \_\_\_\_\_
- 7b. 12% of total body water in liters \_\_\_\_\_
- 7b. 20% of total body water in liters \_\_\_\_\_



| <i>Condition</i>   | <i>Rate of water loss</i> | <i>Survival time in days</i> |
|--|---------------------------|------------------------------|
| 7c. Average water loss for young adult females, 12% total body water loss                  | 2.7 L/day                 |                              |
| 7c. Average water loss during summer for European women (55 kg), 12% total body water loss | 3.3 L/day                 |                              |
| 7e. Absolute minimal water loss possible in humans, 12% total body water loss              | 1.2-1.4 L/day             |                              |
| 7f. Absolute minimal water loss possible in humans, 20% total body water loss              | 1.2-1.4 L/day             |                              |



*Image credit:* “Members of Fairfax County Urban Search and Rescue conduct a rescue operation in a collapsed section of the Hotel Montana in Port-au-Prince, Haiti during a search for survivors of a 7.0 magnitude earthquake. The unit was activated by the U.S. Agency for International Development. Eight people, including 7 Americans, have been rescued from the rubble of the hotel.” PORT-AU-PRINCE, Haiti (Jan. 14, 2010) 100114-N-6266K-033 (U.S. Navy photo by Mass Communication Specialist 1<sup>st</sup> Class Joshua Lee Kelsey/Released) [http://www.navy.mil/view\\_single.asp?id=79928](http://www.navy.mil/view_single.asp?id=79928)

### Part III – Finding other Explanations for Darlene’s Survival

Darlene’s survival was indeed miraculous, but was it based in part on who she was, where she lived (Haiti), and the particular conditions to which she was exposed? Survival can sometimes depend on the smallest of advantages.

#### Questions

8. Would a middle-aged, northern European (or American) male tourist in Haiti have fared as well as Darlene? Are there physiological advantages of being a young female, born and raised in Haiti? Describe how these characteristics might have given her an advantage. In answering this question, consider the following:
  - a. Could being buried in rubble in the warm, humid environment of Haiti have been an advantage for Darlene’s survival? Explain how.
  - b. Does age, weight, or sex affect water loss or water requirements (see Sawha et al., 2005)?
  - c. Does the fact that Darlene was born and raised in Haiti matter? Describe the role that heat acclimation might play in her water balance.
9. Darlene survived a prolonged period of starvation, an additional physiological challenge for her body. Paradoxically, starvation might actually offset and/or minimize some water loss. How?

#### References

Refer to the following website for information about dehydration:

Sawka, M., S.N. Cheuvront, and R. Carter. 2005. Human water needs. *Nutrition reviews* 63: S30-S39.  
<http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA435156&Location=U2&doc=GetTRDoc.pdf>

Westerterp, K.R., G. Plasqui, and A.H.C. Goris. 2005. Water loss as a function of energy intake, physical activity, and season. *British Journal of Nutrition* 93: 199-203.  
<http://journals.cambridge.org/action/displayFulltext?type=1&fid=917992&jid=BJN&volumeId=93&issueId=02&aid=917980>

## Part IV – An Answer?

Some residents thought that Darlene had been trapped in a bathroom, where she was showering at the time of the earthquake. Darlene told rescuers she had a little Coca-Cola with her when the earthquake struck – but was there enough precious liquid for her to survive 15 days? From the newspaper article at the beginning of the case, we know that Darlene probably did not exhibit the maximal dehydration that would have resulted in her losing consciousness (i.e., >12% body water loss).

### Questions

- Based on your calculations above, how much water would Darlene have needed to consume daily to reduce the rate of her dehydration such that she lost a maximum of only 10% of her body water after 15 days?



*Image credit:* “Search and Rescue teams from France, Haiti, Turkey, Fairfax County, Va. and members of the U.S. Air Force 23<sup>rd</sup> Special Tactics Squadron place Hotline Lozoma, a 25-year-old Haitian woman, on a stretcher after extracting her from the rubble of a collapsed market. Units from all branches of the U.S. military are conducting humanitarian and disaster relief operations as part of Operation Unified Response after a 7.0 magnitude earthquake caused severe damage in Haiti Jan. 12.” PORT-AU-PRINCE, Haiti (Jan. 19, 2010) 100119-N-8878B-767 (U.S. Navy photo by Mass Communication Specialist 2<sup>nd</sup> Class Michael C. Barton/Released) [http://www.navy.mil/view\\_single.asp?id=80347](http://www.navy.mil/view_single.asp?id=80347)



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