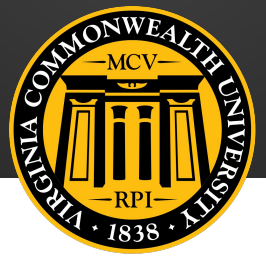
Understanding Mortality and Aging

Utilizing data-mining techniques to find conserved patterns in the different global causes of mortality



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COMPLEXITY

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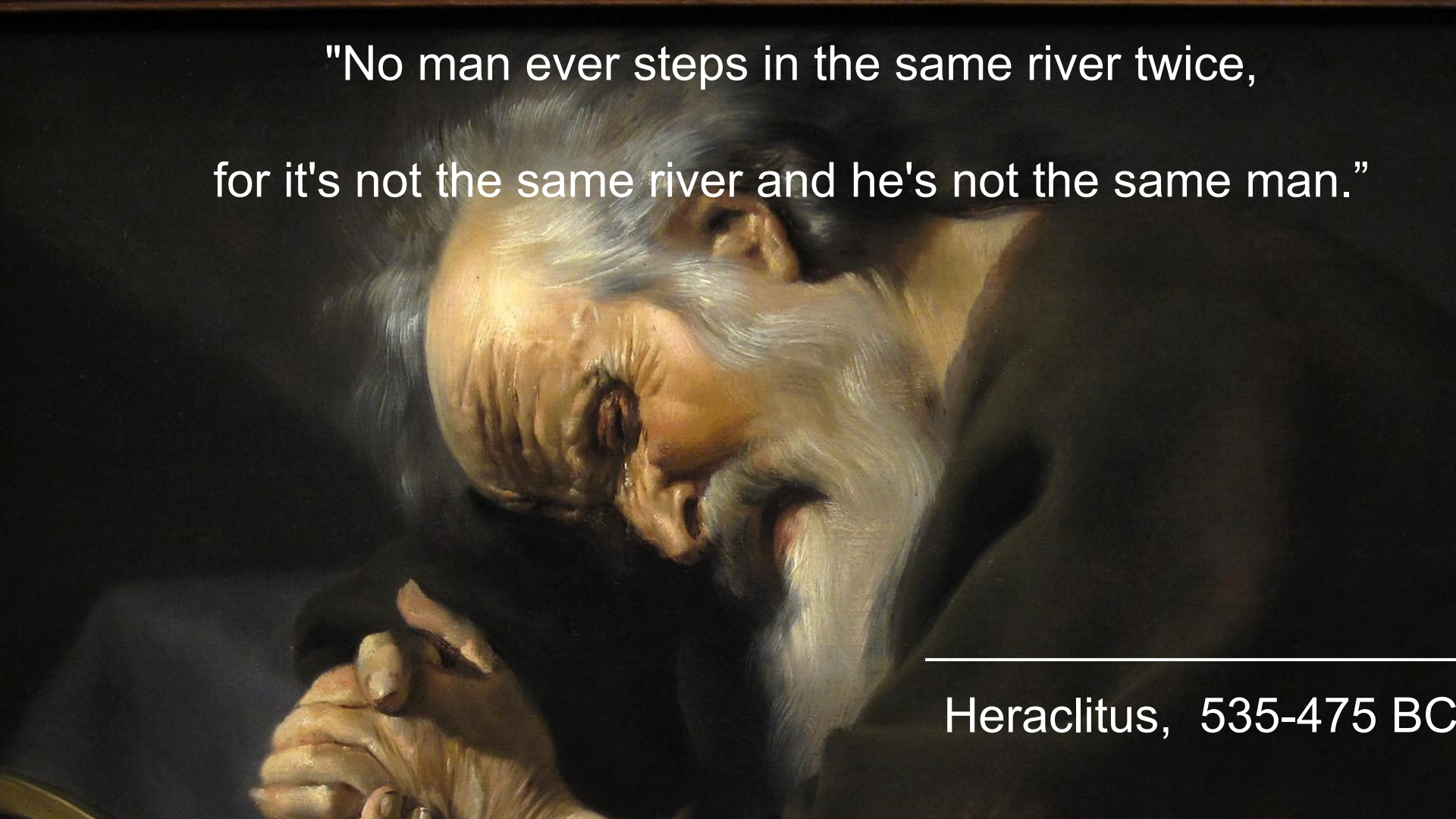
"No man ever steps in the same river twice,
for it's not the same river and he's not the same man."
Heraclitus, 535-475 BC

What is Biodemography?

- Biodemography is an amalgamation of the biological sciences and demography
- Biodemographers seeks to understand how the biological determinates of death and birth vary across populations[1]

1. Crimmins, Eileen, Jung Ki Kim, and Sarinnapha Vasunilashorn. "Biodemography: New Approaches to Understanding Trends and Differences in Population Health and Mortality." *Demography* 47.S (2010). Print.

Exhaustive Searches

- A class of iterative methods typically used to solve discrete problems where no efficient solution method is known[2]
  - Also known as Brute Force Searches
- This method enumerates through all possible combinations of a given set to test each candidate (or each generated combination) against a predefined problem statement
  - Easy to implement, easy to program

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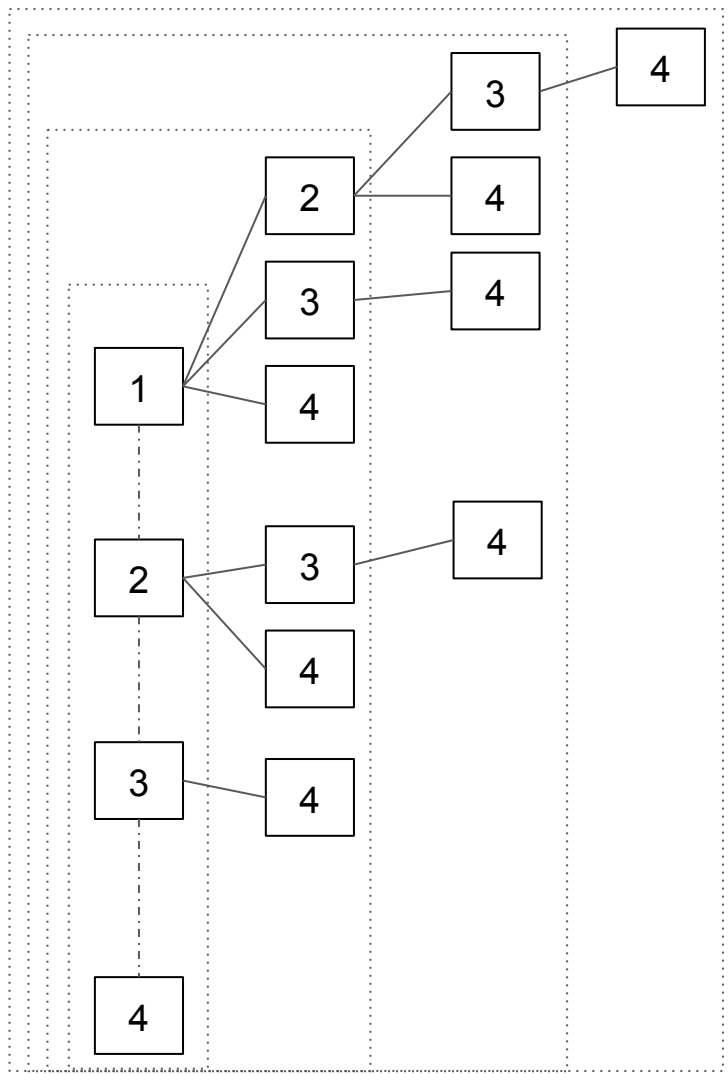
2. "Brute-force Search." *Wikipedia*. Wikimedia Foundation, 04 Aug. 2017. Web. 07 Aug. 2017.



Exhaustive Search of set S {1,2,3,4} yielding k-itemsets

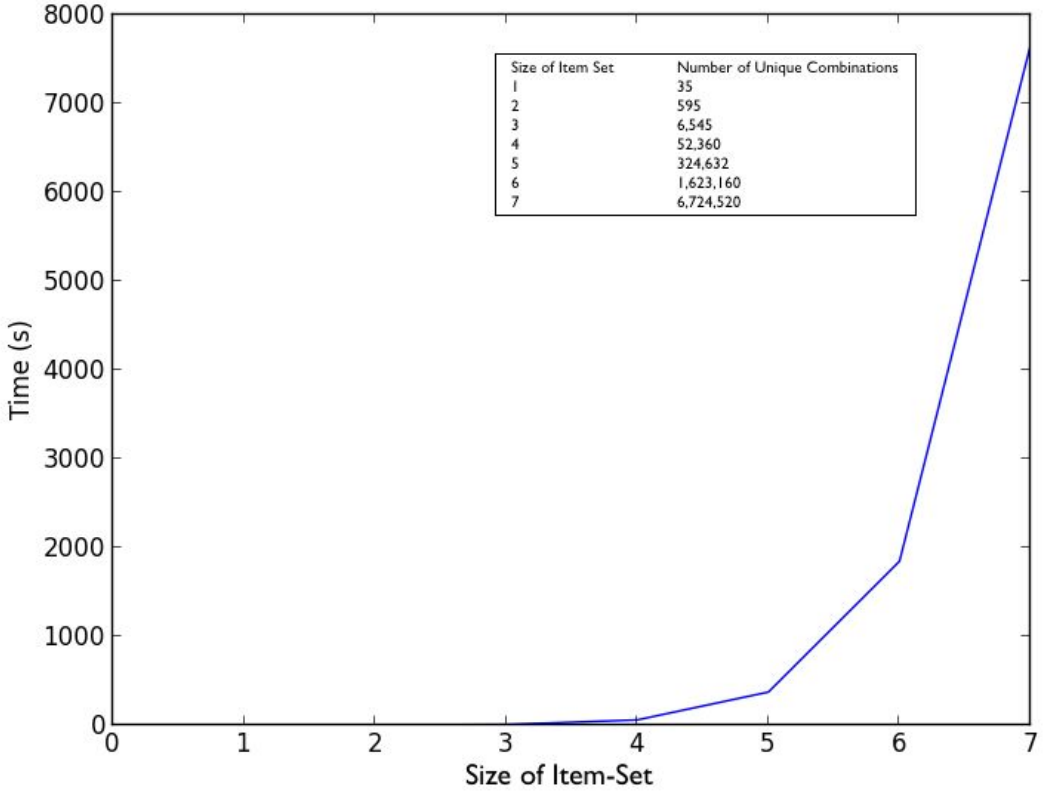
1-itemsets	2-itemsets	3-itemsets	4-itemsets
{1}	{1,2}	{1,2,3}	{1,2,3,4}
{2}	{1,3}	{1,2,4}	
{3}	{1,4}	{1,3,4}	
{4}	{2,3}	{2,3,4}	
	{2,4}		
	{3,4}		

Disadvantages of Exhaustive Searches

- Suffers from severe performance issues
- As the size of the set to be permuted grows, the time complexity increases in a polynomial manner
  - O(n^k): where n is the cardinal number of the set and k is the cardinal number of the candidate itemset[3]
  - Last resort option

3. "Computational Complexity Theory." *Wikipedia*. Wikimedia Foundation, 06 Aug. 2017. Web. 07 Aug. 2017.

Combinatorial explosion of k-itemset generation in an exhaustive search of set S {1,2,3,4,5,6,7,..., 35}



Observed

Itemset Cardinality	Generative Timing (secs)
0	0.0
1	0.04
2	0.68
3	7.39
4	59.46
5	373.39
6	1845.85
7	7660.54

Extrapolated

Itemset Cardinality	Generative Timing (secs)
8	26934.39
10	210088.26
12	954946.64
14	2654961.54
16	4646182.69
18	5192792.42
20	3716946.15
35	0.0011444

Decades you say, no problem!

… 44 years later

```
>>> primt("Done!")

Traceback (most recent call last):

File "<stdin>", line 789, in <module>

NameError: name 'primt' is not defined


>>> print("Hello Darkness, my old friend!")
```

Metaheuristics

- Alternative to exhaustive search methods that can be employed to find a sufficient solution in a set which is too large to be completely sampled[4]
  - Uses a heuristic to cut off subsets of the search, effectively reducing search space and runtime[5]
  - Does not always yield a global optimal solution (a solution to all possible combinations)[4, 6]

4. Blum, Christian, and Andrea Roli. "Metaheuristics in Combinatorial Optimization." *ACM Computing Surveys* 35.3 (2003): 268-308. Print..
5. Yang, Xin-She. "Metaheuristic Optimization." *Scholarpedia* 6.8 (2011): 11472. Print.
6. "Computational Complexity Theory." *Wikipedia*. Wikimedia Foundation, 06 Aug. 2017. Web. 07 Aug. 2017.

Computational Complexity Theory

- Field that identifies the inherent difficulty that some problems yield and classifies them accordingly[6]

- Biggest unsolved problem is whether P = NP
  - If true, it would mean that all very hard problems have seemingly easy solutions
    - Implications of this proof would be drastic and widespread

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6. "Computational Complexity Theory." *Wikipedia*. Wikimedia Foundation, 06 Aug. 2017. Web. 07 Aug. 2017.

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Apriori Algorithm

- Robust metaheuristic used in data mining for the evaluation of frequent itemsets for boolean association rules
  - Heuristic evaluates itemsets which have met a minimum support (a count of how frequently the itemset appears within the dataset or database).
  - Based off of the apriori property which states that any subset of a frequent itemset must also be frequent[1]

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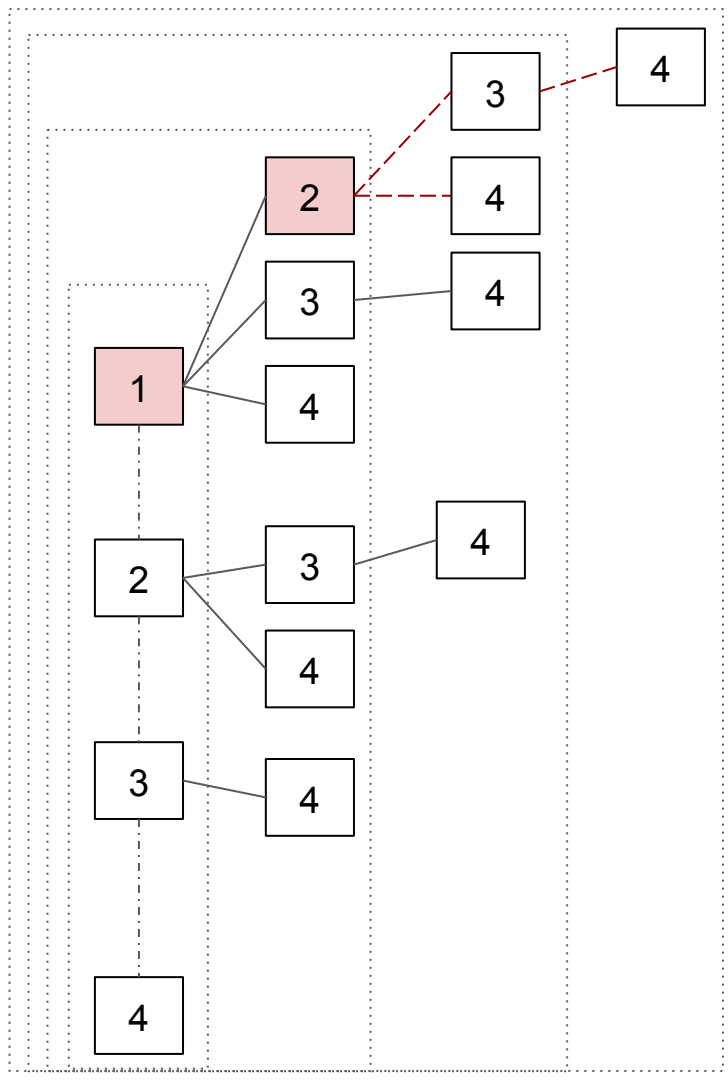
7. Adamo, Jean-Marc. "Apriori and Other Algorithms." *Data Mining for Association Rules and Sequential Patterns* (2001): 33-48. Print.



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{2}	{1,3}	{1,2,4}	
{3}	{1,4}	{1,3,4}	
{4}	{2,3}	{2,3,4}	
	{2,4}		
	{3,4}		

Apriori Algorithm of set S {1,2,3,4} yielding k-itemsets

1-itemsets	2-itemsets	3-itemsets	4-itemsets
{1} ✓	{1,2} ✘	~~{1,2,3}~~	~~{1,2,3,4}~~
{2} ✓	{1,3} ✓	~~{1,2,4}~~	
{3} ✓	{1,4} ✓	{1,3,4} ✓	
{4} ✓	{2,3} ✓	{2,3,4} ✓	
	{2,4} ✓		
	{3,4} ✓		

Adapted Apriori Algorithm

- Heuristic: p-value threshold
  - For each country, an itemset frequency is calculated by summating the frequencies for each item in a generated k-itemset; these k-itemset frequencies are then evaluated with a one-way chi-squared test to find whether there's a significant difference between each countries observed frequency.
    - If a candidate k-itemset does not meet this threshold then its search space is effectively pruned.

H_o: C_1k-itemset = C_2k-itemset = … = C_6k-itemset

H_A: C_ik-itemset ≠ C_jk-item

Pipeline

- Step I: Data preprocessing: “preproces.py”
  - Cleans up the datasets, before any data analysis begins, the function “pre_process_data” will analyze all columns containing icd code mortality rates, and it will replace null fields with “0”
    - If not done, problems will arise when the chi-squared analysis begins
  - The program’s second major role is to parse each of the datasets (which contain data on the top icd mortality rates for a range of ages for a given country) by biological sex into two new files-- instantiated if there is not a 1:2 ratio between datafile types

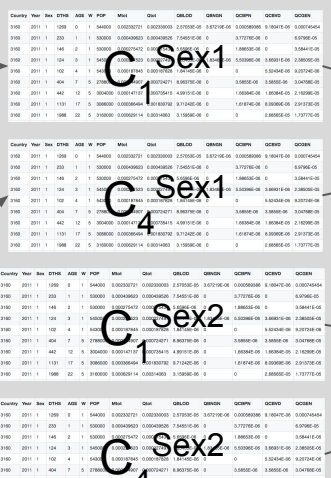
Pipeline

- Step II: Data management: “pipeline.files2dictionary(filename, country_ID, supp_dict)”
  - For the management and housing of all the project’s data, two dictionaries were created to house all the data for each biological sex (~six datasets)
  - Each age was evaluated to see if it met the minimum support (~6 or the number of countries)
    - If an age did not meet the minimum support, then one or more of the data set(s) did not contain any information on that age group, and that age was not evaluated. *The goal is to find diseases or groups of diseases conserved across all six countries.*

Pipeline

- Step III: Data analysis: “pipeline.apriori_v3(q, insig, sex_file_dict, countries_list, age)”
  - To implement this algorithm, a queue and a list of insignificant itemsets were used generate tentative candidates
    - If an itemset was found to be significant, it was added to the queue and appended to a list of significant itemsets
    - If found to be insignificant, the tentative candidate was popped from the queue
- This effectively and efficiently reduces the algorithm’s search space from years to mins.

Step I: Data Preprocessing



Sex 1

[country][age][icd] = freq

Sex 2

[country][age][icd] = freq

Step II: Data Management

Set S = {1,2,3,4}

Countries: C_1 C_2 C_3 C_4

{1} = chi_square([32, 40, 30, 20]) ✓

{2} = chi_square([8, 15, 5, 6]) ✓

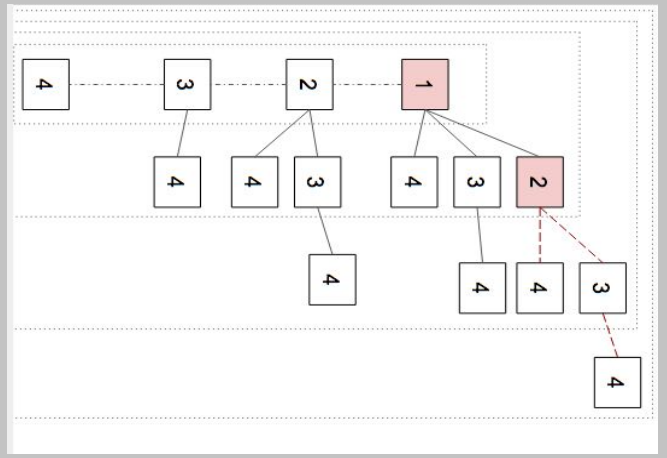
$\{1,2\}_K$ [40, 55, 35, 26]+

C_1 C_2 C_3 C_4

{1,2} chi_square([40,55,35,26]) ✘

p-value < alpha

Does not get added to the Queue!



1-itemsets

{1} ✓

{2} ✓

{3} ✓

{4} ✓

2-itemsets

{1,2} ✘ = [40,55,35,26]

{1,3} ✓

{1,4} ✓

{2,3} ✓

{2,4} ✓

{3,4} ✓

3-itemsets

~~{1,2,3}~~

~~{1,2,4}~~

{1,3,4} ✓

{2,3,4} ✓

4-itemsets

~~{1,2,3,4}~~

Step III: Data Analysis

Special Acknowledgements

It is of genuine pleasure to express my deepest sympathies to you all today. None of this would have been possible without you; thank you for your timely feedback, contagious kindness, and boundless knowledge that has enabled myself to accomplish this tumultuous task. And for that, I say thank you!

Thank you for supporting the power of mentorship. I believe it has the power to transform the world into a better place. The passing of knowledge is one of humanity's most sacred acts of veneration. I am humbled and honored to have worked with each one of you.

Sincerely,

Skyler Kuhn

References

1. Crimmins, Eileen, Jung Ki Kim, and Sarinnapha Vasunilashorn. "Biodemography: New Approaches to Understanding Trends and Differences in Population Health and Mortality." *Demography* 47.S (2010). Print.
2. "Brute-force Search." *Wikipedia*. Wikimedia Foundation, 04 Aug. 2017. Web. 07 Aug. 2017.
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#primt(“Done!”)

print(“Done!”)