

# Skilled Technical Workforce: Supply, Demand, and Pathways

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Data Science for the Public Good

Summer 2019

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Vicki Lancaster, Ph.D., Sam Cohen, Ph.D.



UNIVERSITY  
*of* VIRGINIA

Biocomplexity Institute & Initiative

# Data Science for the Public Good

## Skilled Technical Workforce (STW) Team

NCSES	John Finamore	Program Director, Human Resources Statistics Program
UVA	Alyssa Fowers	Data Science for the Public Good Fellow
UVA	Calvin Isch	Data Science for the Public Good Intern
UVA	Sarah McDonald	Data Science for the Public Good Intern
UVA	Vicki Lancaster	Principal Scientist
UVA	Samantha Cohen	Postdoctoral Research Associate
UVA	Devika Nair	Research Scientist
UVA	Nathaniel Ratcliff	Assistant Research Professor

# What is the Skilled Technical Work (STW)?

A job in the STW requires\*:

1. A high level of knowledge in a technical domain; but
2. Does not require a bachelor's degree for entry.

Skilled Technical Work:

- Is critical to the nation's ability to innovate and compete in the global economy; and
- Can be a pathway for the individual to the middle class.

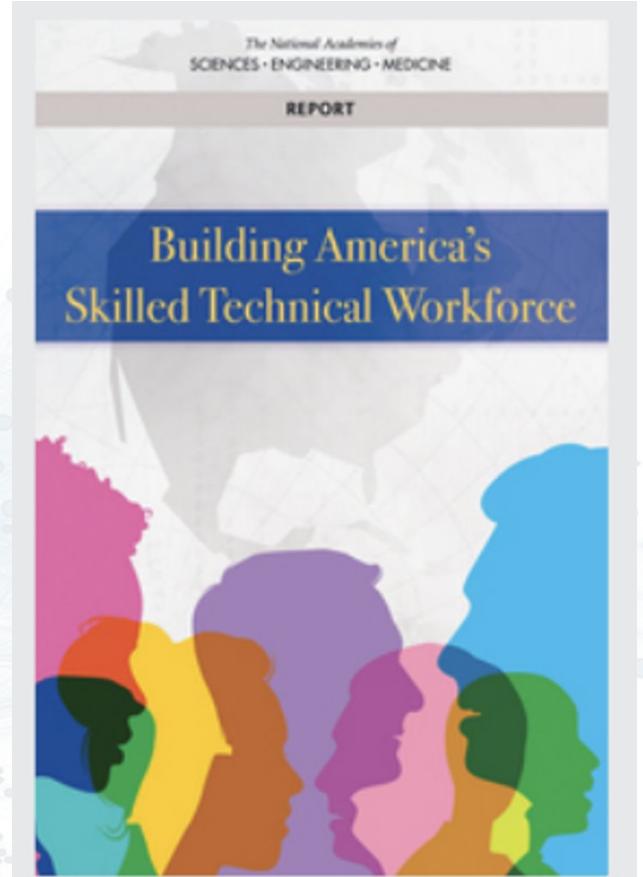
\*Rothwell JT, (September 1, 2015) Skilled Technical Work (September 1, 2015). Available at SSRN: <https://ssrn.com/abstract=2709141> or <http://dx.doi.org/10.2139/ssrn.2709141>

# Why study the STW?

More precise understanding can lead to policy reforms that enhance the economic well-being of both the nation and individual.

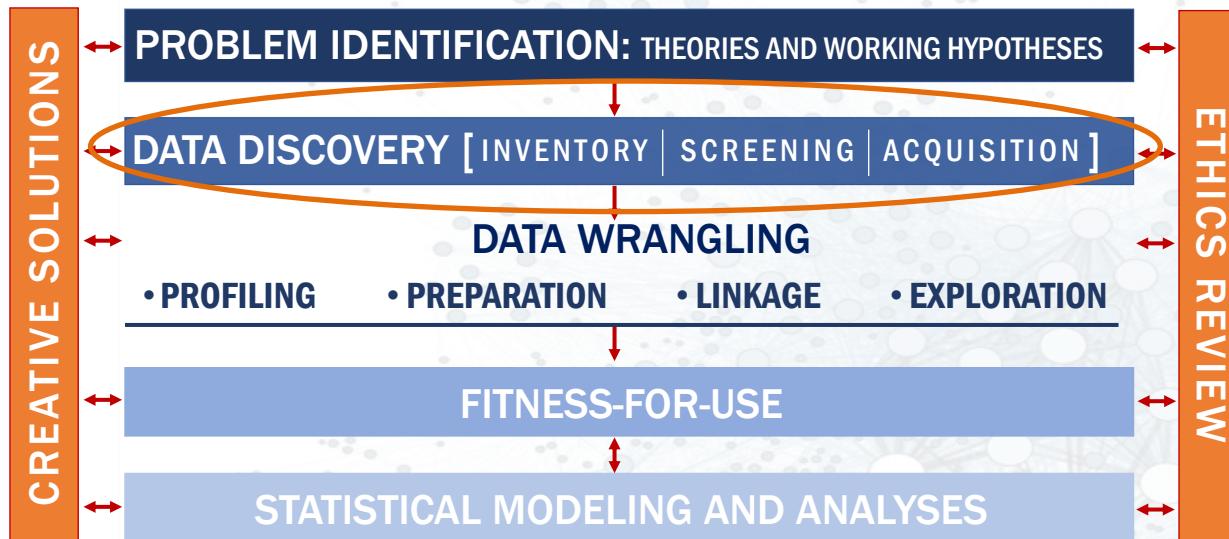
*“Better data and better analyses of data are needed to make progress in understanding and addressing the challenges of skilled technical workforce development.”*

National Academies report, Building America's Skilled Technical Workforce (2017)



# Why study the STW?

Currently there are no federal surveys that measure the prevalence and pathways to non-degree credentials.



# Research Questions

- What are the most in-demand skilled technical occupations in Virginia?
- Can we evaluate the match between demand and supply for skills in the STW?
- What pathways besides a 4-year degree will provide the skills necessary to secure a job in the STW?

# Proof of Concept

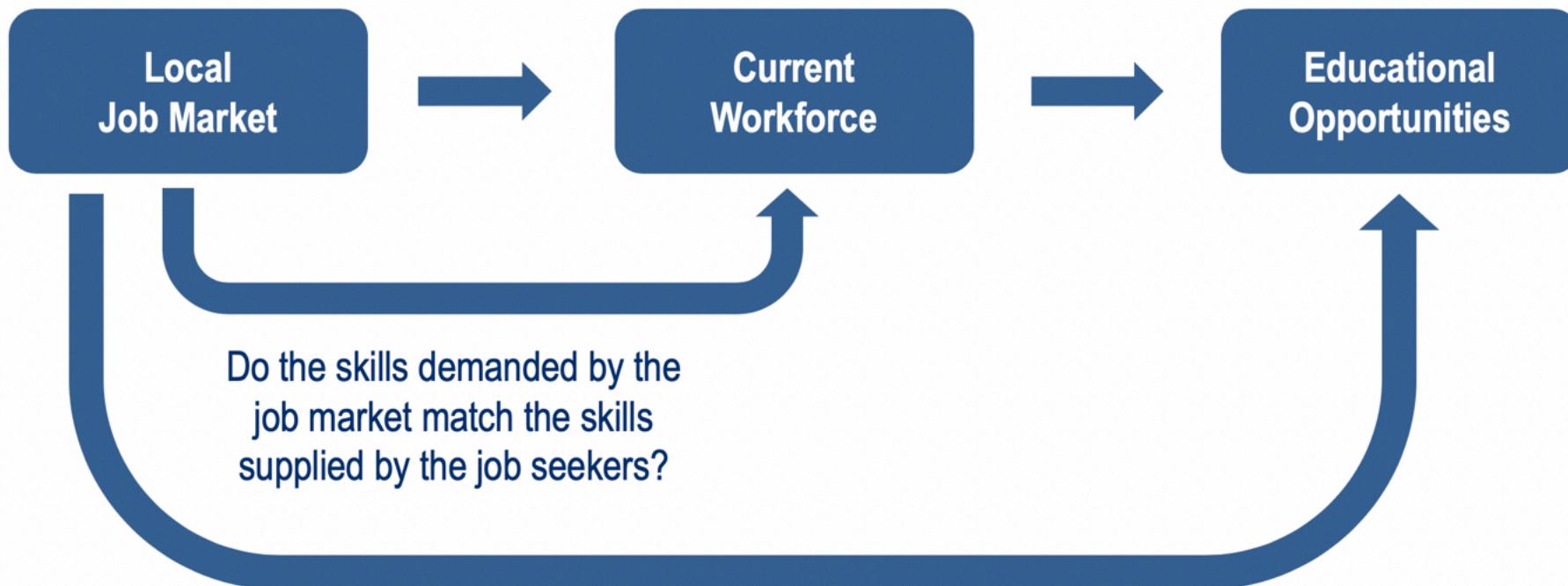
Can we use "existing" data to understand the skills needed for in-demand skilled technical occupations, and how those compare to the skills available in the local labor force?



What STW positions are available? What skills are required for those jobs?

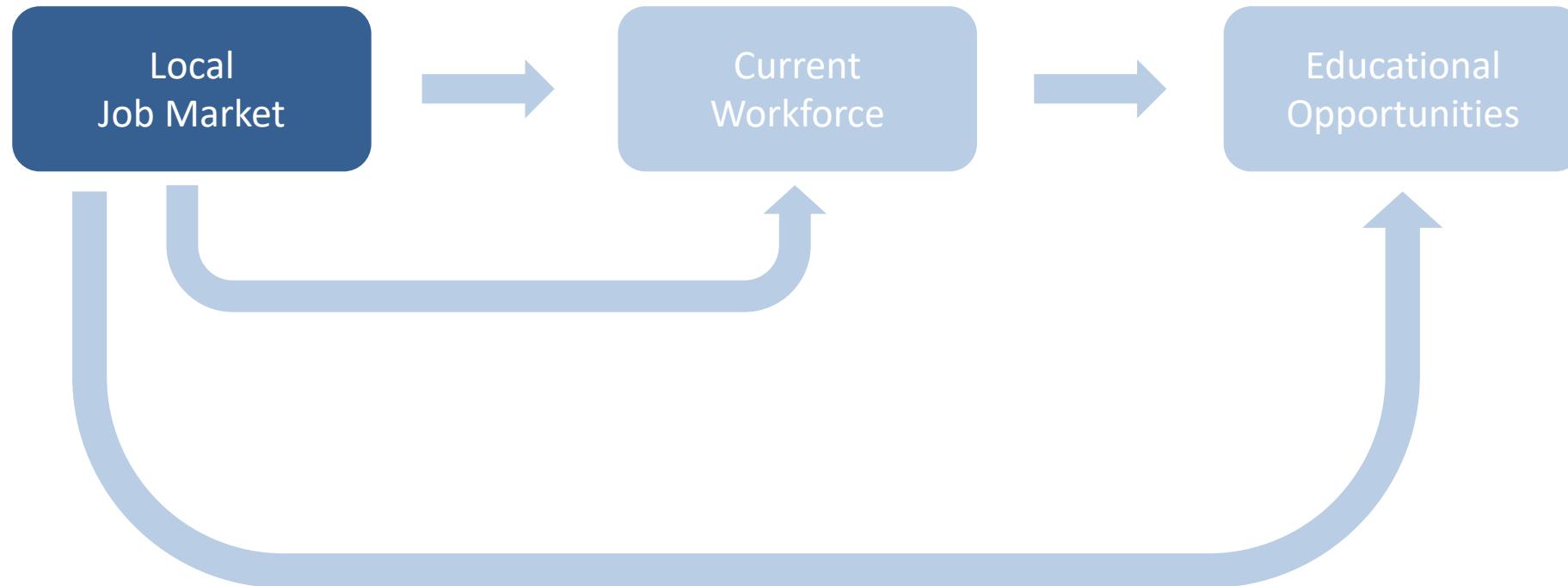
What skills do job seekers have?

Where can job seekers train for a position in the STW?



# Describing the Local Job Market With Online Job-Ads

What STW positions are available? What skills are required for those jobs?





\* <https://www.burning-glass.com/about/>



**burningglass<sup>®</sup>**  
TECHNOLOGIES

50,000  
sites daily

70  
variables

2007,  
2010-19

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TECHNOLOGIES

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2007,  
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MSA

O\*NET Code

Education

**Skills Requested**

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TECHNOLOGIES

50,000  
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### Known Data Bias

Skewed toward jobs with higher levels of education

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# Augmentations of Job-Ad Data



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## 1. STW Jobs

Rothwell STW Parameters



**O\*NET OnLine**



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Rothwell STW Parameters



**O\*NET OnLine**



## 2. Hard/Soft Skills



# Augmentations of Job-Ad Data

- A "**soft skill**" is personality-based, primarily used to interact with coworkers, or a general way of approaching a problem.
  - "Teamwork"
  - "Creativity"
- A "**hard skill**" requires domain-specific knowledge or can be easily measured and evaluated.
  - "Microsoft Excel"
  - "Bayesian Statistics"

# Augmentations of Job-Ad Data

## 1. STW Jobs

Rothwell STW Parameters



**O\*NET OnLine**



## 2. Hard/Soft Skills

Define Hard/Soft Skills



STW Jobs of Interest



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# Augmentations of Job-Ad Data

## 1. STW Jobs Changes    2. Hard/Soft Skills    3. Skill Changes

Rothwell STW Parameters



**O\*NET OnLine**



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TECHNOLOGIES

Define Hard/Soft Skills

STW Jobs of Interest



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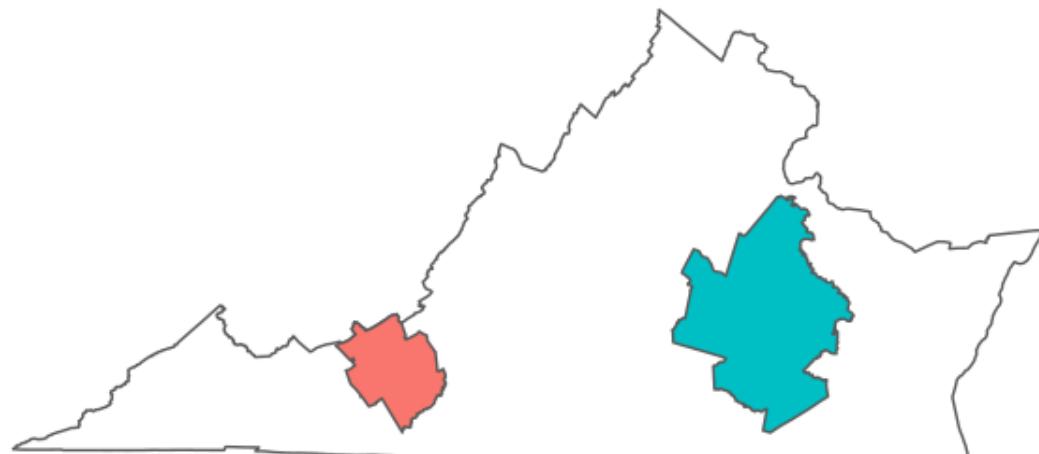
Identify  
'near-duplicate'  
skills



Group together

# Focus on Richmond and Blacksburg

Job-ads and MSAs Used for Analysis



Selected two metropolitan statistical areas (MSAs) in 2016-17:

- Richmond  
(Population 1,292,911)
- Blacksburg-Christiansburg-Radford  
(Population 182,692)

<https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk>

# Common STW Jobs in our MSAs

## Blacksburg (2,119 STW)

1. 11.6% Critical Care Nurses
2. 9.4% Computer User Support Specialists
3. 6.9% Maintenance and Repair Workers, General
4. 2.1% Emergency Medical Technicians and Paramedics
5. 2.0% Automotive Specialty Technicians

## Richmond (18,598 STW)

1. 8.7% Critical Care Nurses
2. 7.5% Maintenance and Repair Workers, General
3. 5.6% Computer User Support Specialists
4. 3.2% Automotive Specialty Technicians
5. 2.7% Web Developers

# Common STW Jobs in our MSAs

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**Selected Critical Care Nurses (CCN) for a case study**

# Ads for Critical Care Nurses in Richmond and Blacksburg

All Virginia job ads, 2016-2017: 1,486,697

*Filter By MSA*

All Richmond job ads:  
205,285

*Filter By MSA*

All Blacksburg job ads:  
24,358

*Filter via O\*NET  
and Bachelor's  
Requirement*

STW Richmond job ads:  
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*Filter via O\*NET  
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*Filter By  
O\*NET Again*

Critical Care Nurse ads in  
Richmond:  
1,609

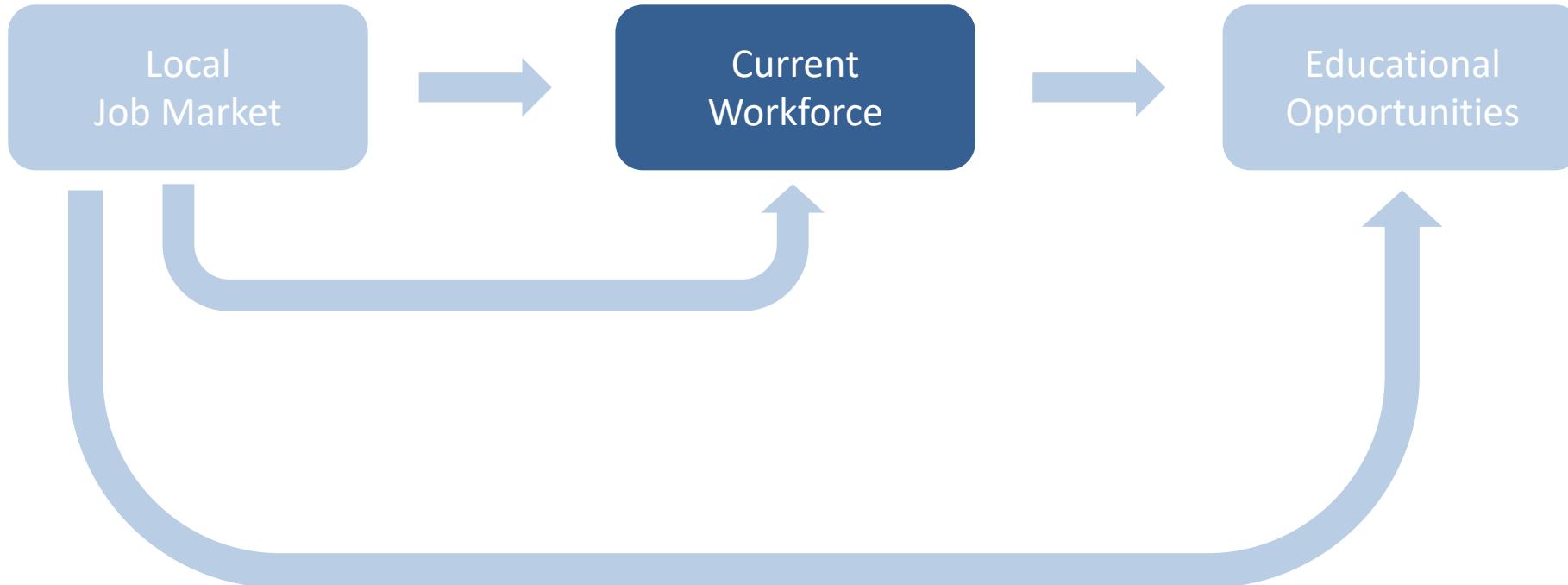
*Filter By  
O\*NET Again*

Critical Care Nurse ads in  
Blacksburg:  
245

# Describing the Current Workforce with Online Resumes

What STW positions are available? What skills are required for those jobs?

What skills do job seekers have?



# BGT Resume Data

BGT proprietary dataset, sourced from Burning Glass partners.

- Benchmarked against BLS data for age, education, resume address, and SOC occupation (Schubert, Stansbury, & Taska (2019))

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- Originally 2200 zipped files; merged into 5 unique data-tables:
  - Personal information, skills, education, certifications, job history

# BGT Resume Data

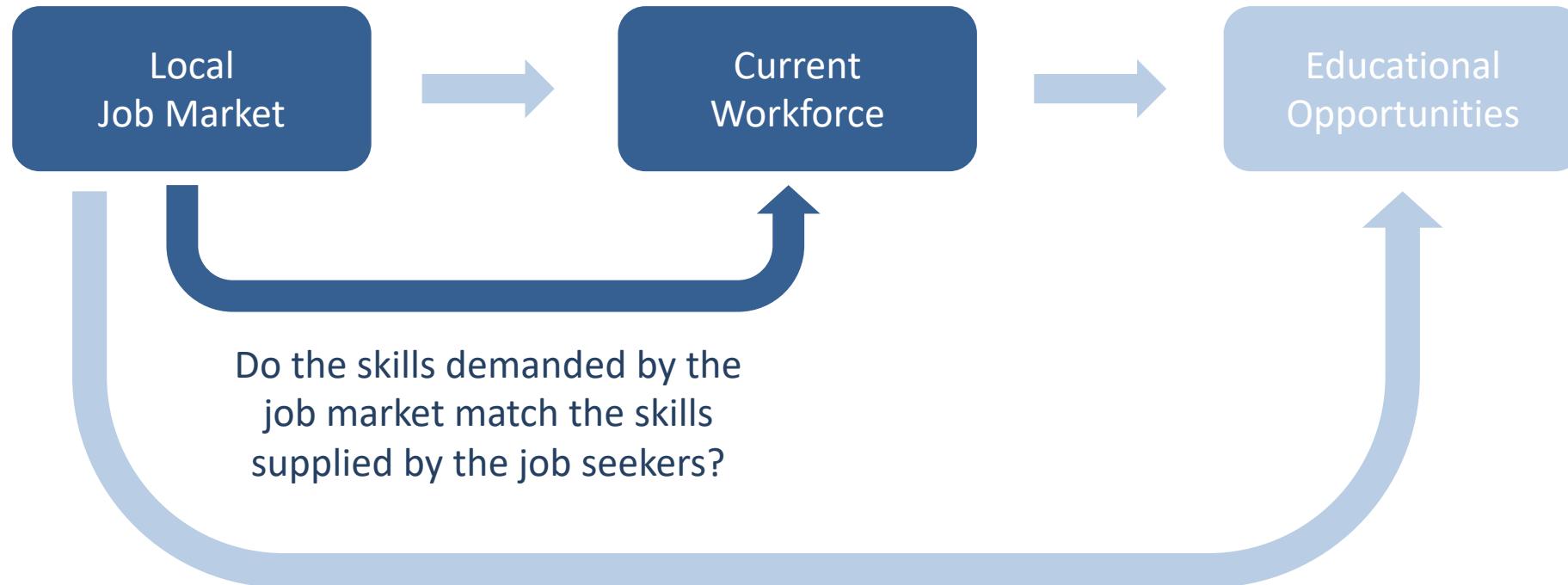
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- Originally 2200 zipped files; merged into 5 unique data-tables:
  - Personal information, skills, education, certifications, job history
- Analyzed two MSAs using 2016-17resume data:

Blacksburg:  
**10,428**

Richmond:  
**91,916**

# Connecting Ads to Resumes With Burning Glass Skills Data



# Identifying Plausible Candidates for STW: Critical Skills

1. Identify *critical skills*: hard skills in over 25% of job ads
  - Excluding extremely common hard skills, e.g. "Teaching"
2. Select resumes with at least one critical skill

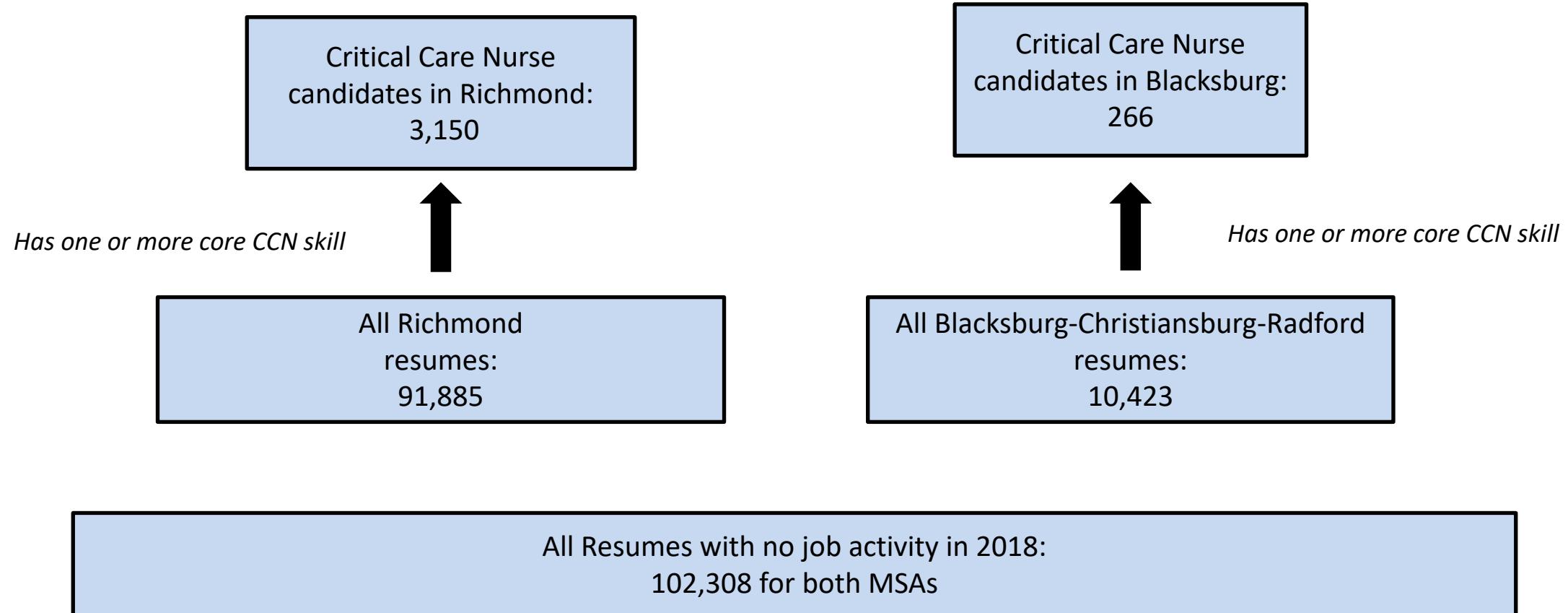
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2. Select resumes with at least one critical skill

## Critical Skills:

- Richmond: Critical Care, Advanced Cardiac Life Support, Patient Care, and Neonatal Intensive Care Unit
- Blacksburg: Critical Care, Advanced Cardiac Life Support, Patient Care

# Ads for Critical Care Nurses in Richmond and Blacksburg



All Virginia job ads, 2016-2017: 1,486,697



Critical Care Nurse ads in  
Richmond:  
1,609

Critical Care Nurse ads in  
Blacksburg:  
245

Critical Care Nurse  
candidates in Richmond:  
3,150

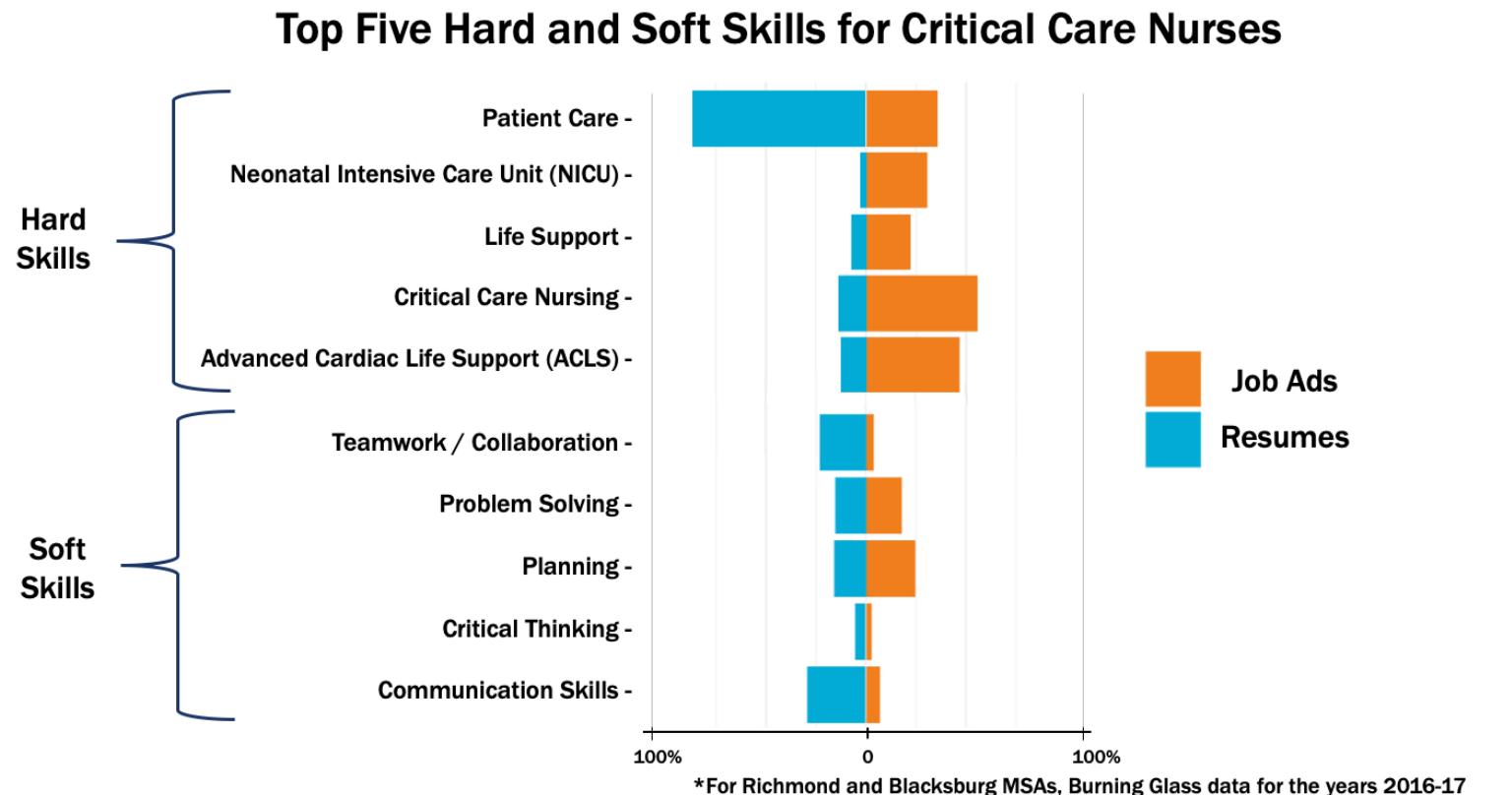
Critical Care Nurse  
candidates in Blacksburg:  
266



All Resumes with no job activity in 2018:  
102,308 for both MSAs

# Skill Differences Between Job Ads and Resumes

- Most hard skills are undersupplied
- Most soft skills are oversupplied.
- Some skills appear to be extremely undersupplied (NICU)



# Determining Match Between Ads and Resumes

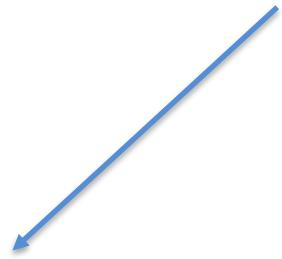
Sample Resume

Life Support	Trauma	NICU	Patient Care
✓	✓		✓

Proportion of requested skills fulfilled by resume

Match With Ad

	Life Support	Trauma	NICU	Patient Care	Matching Skills	# of Skills Requested	Match Score
Job 1	✓	✓	✗	✓	1	2	0.5
Job 2	✓	✓	✓	✓	3	3	1
Job 3	✓	✓	✗	✓	0	1	0
Job 4	✓	✓	✗	✓	3	4	0.75



# Determining Match Between Ads and Resumes

Sample Resume

Life Support	Trauma	NICU	Patient Care
1	1	0	1

Match With Ad

	Life Support	Trauma	NICU	Patient Care	Matching Skills	# of Skills Requested	Match Score
Job 1	1	0	1	0	1	2	0.5
Job 2	1	1	0	1	3	3	1
Job 3	0	0	1	0	0	1	0
Job 4	1	1	1	1	3	4	.75

# Determining Match Between Ads and Resumes

The skills requested in each ad were compared to the skills listed on each resume, resulting in a match score for each resume and each job.

	Job 1	Job 2	Job 3	Job 4
Resume 1	0.5	1	0	.75
Resume 2	0	.33	0	.25
Resume 3	1	.67	1	.75
Resume 4	.5	0	1	0

In Richmond, we matched 3,150 resumes to 1,609 job ads across 38 skills.

## Match scores between job ads and candidates: Critical Care Nurses

1,609 job ads matched to 3,150 candidates in Richmond, VA

### How to Read

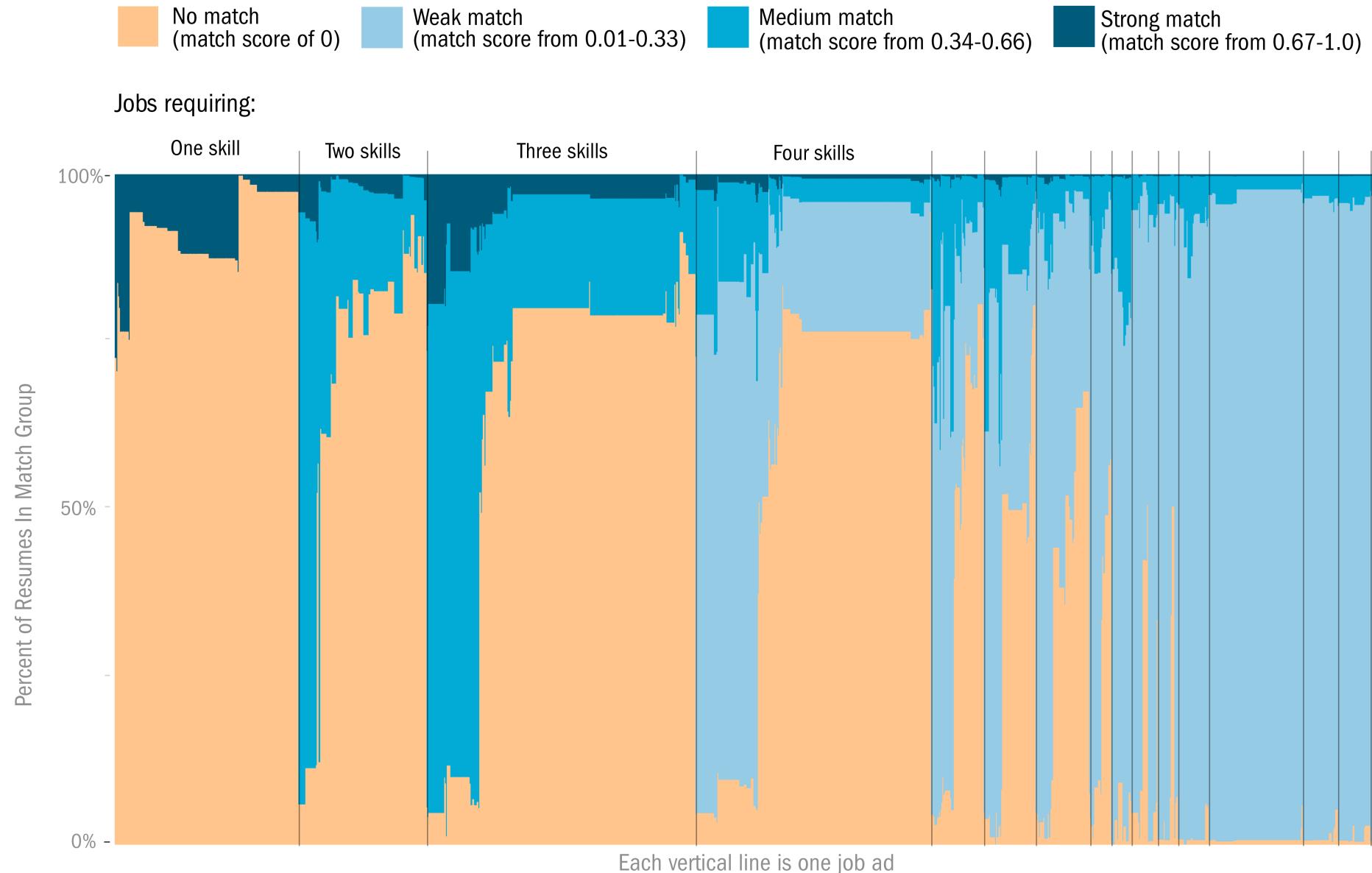
Each vertical line is one job. The colored segments within each line show how many candidates matched to that job at a certain level.

10% of candidates had a strong match to this job (67-100% of requested skills)

20% of candidates had a medium match to this job (34-66% of requested skills)

45% of candidates had a weak match to this job (1-33% of requested skills)

25% of candidates no match to this job (none of the requested skills)



# Match scores between job ads and candidates: Critical Care Nurses

245 job ads matched to 266 candidates in Blacksburg, VA

## How to Read

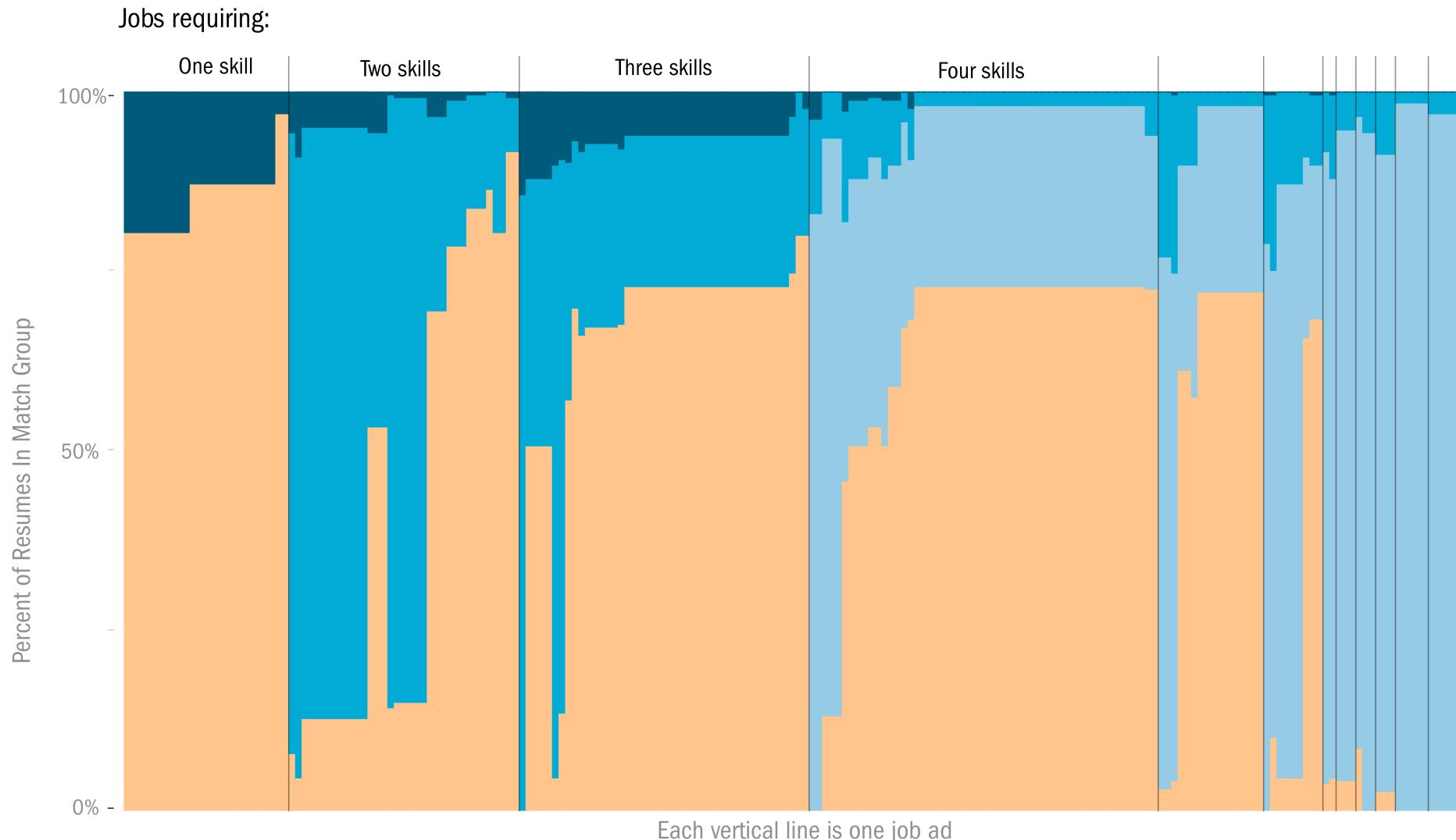
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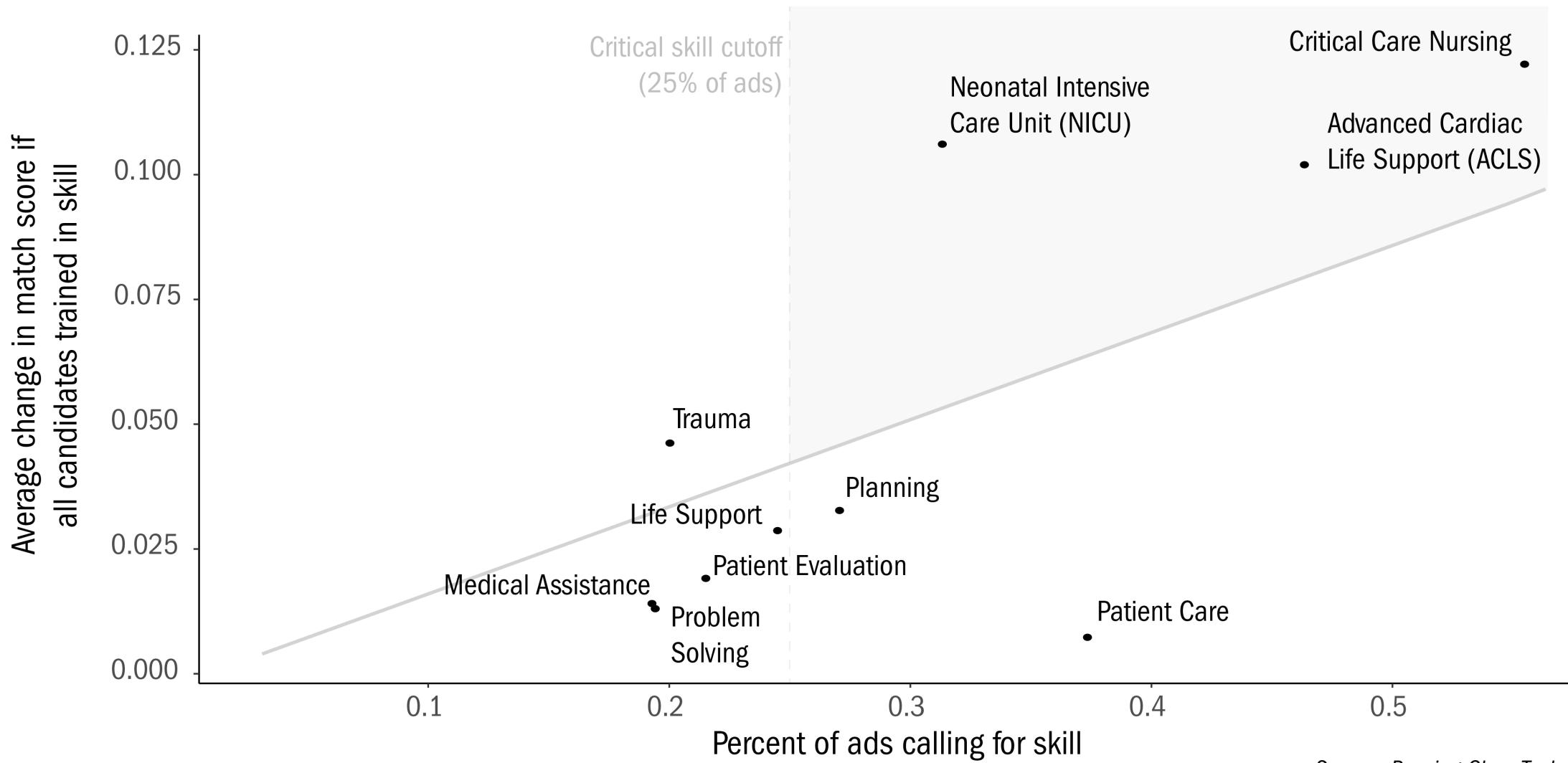
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25% of candidates no match to this job (none of the requested skills)



# Potential Impact of Skill Training on Match Scores

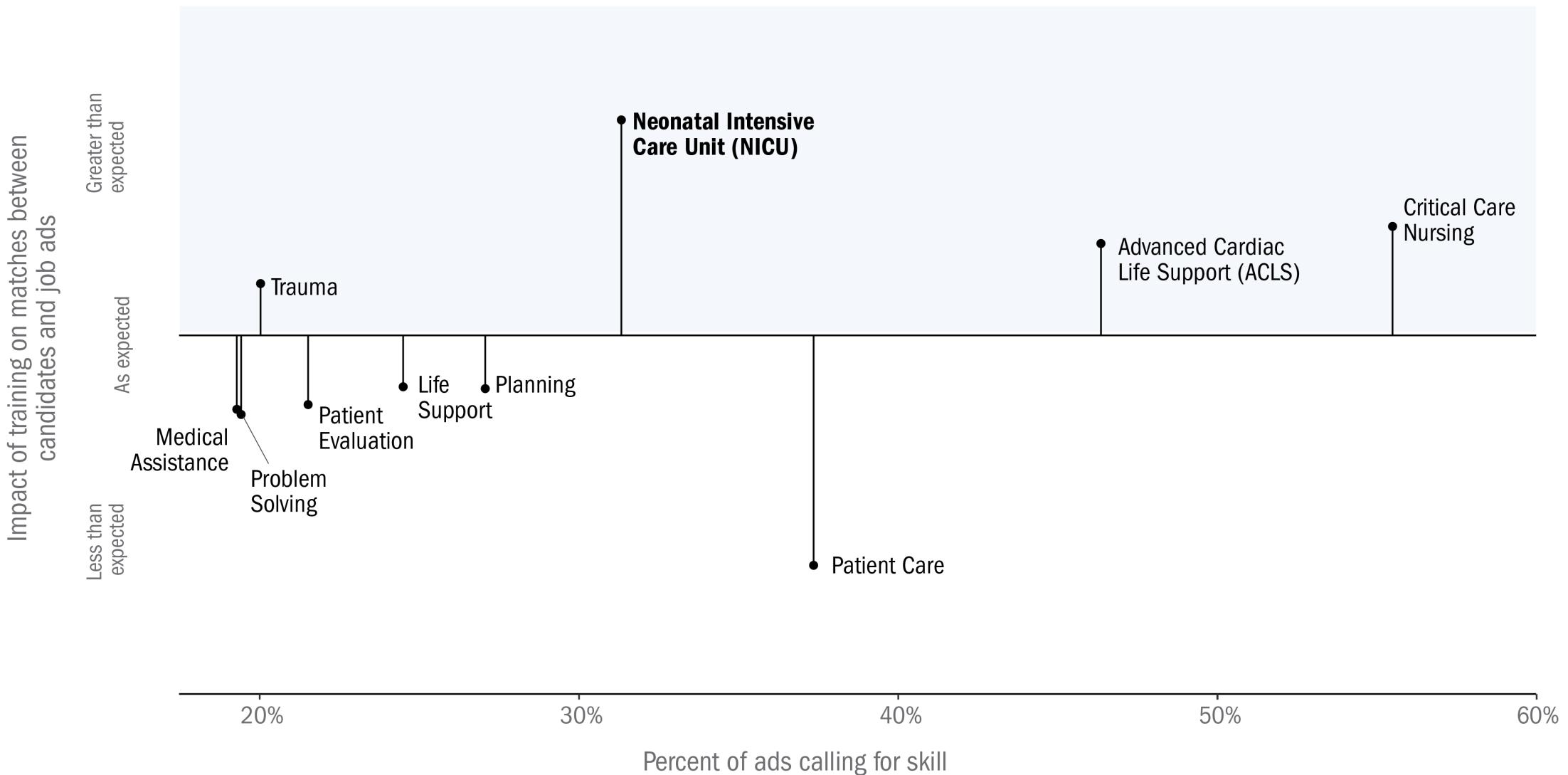
Critical Care Nurses in Richmond, VA



Source: Burning Glass Technologies

# Impact of additional skill training on matches to Critical Care Nursing jobs

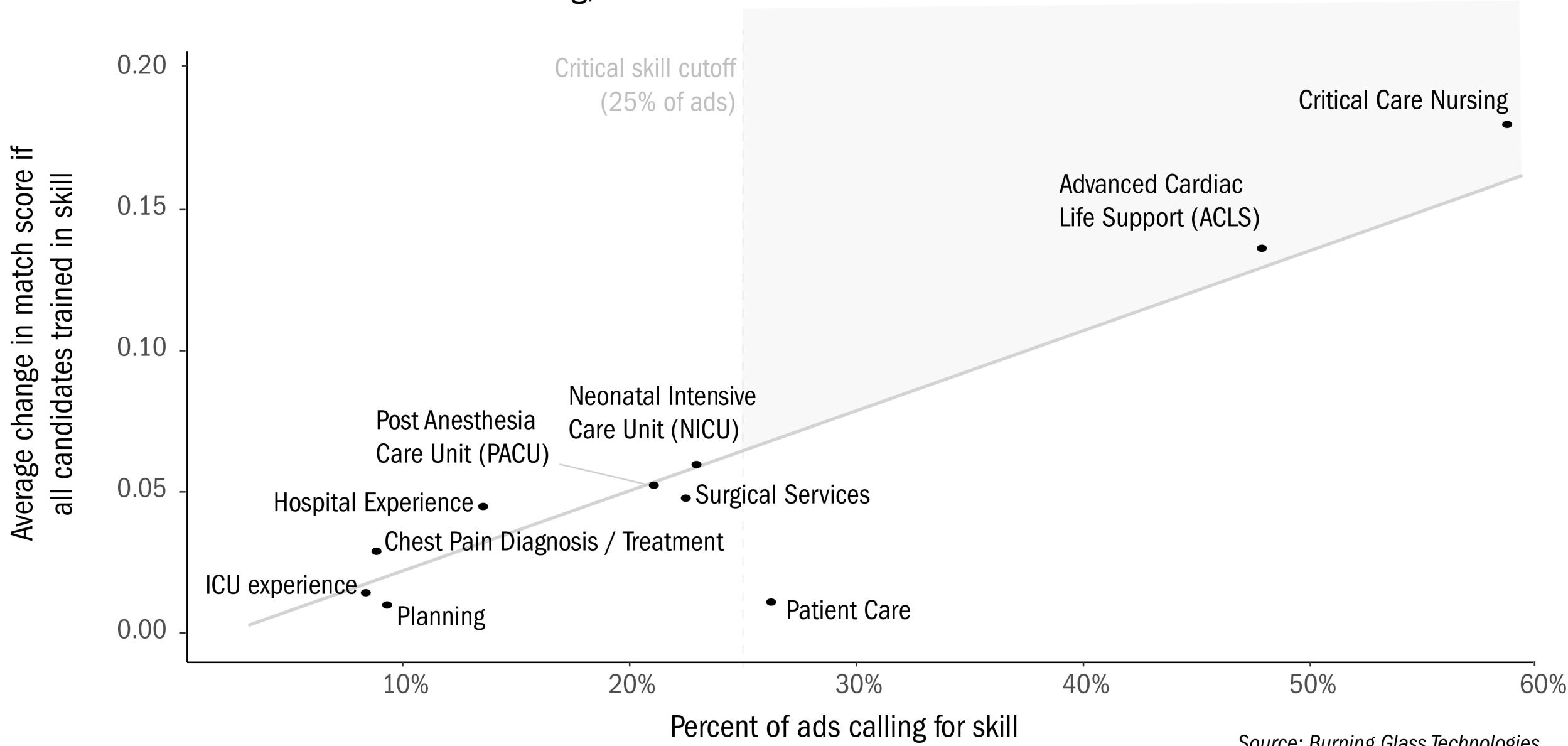
Richmond, VA, 2016-2017



Source: Burning Glass Technologies

# Potential Impact of Skill Training on Match Scores

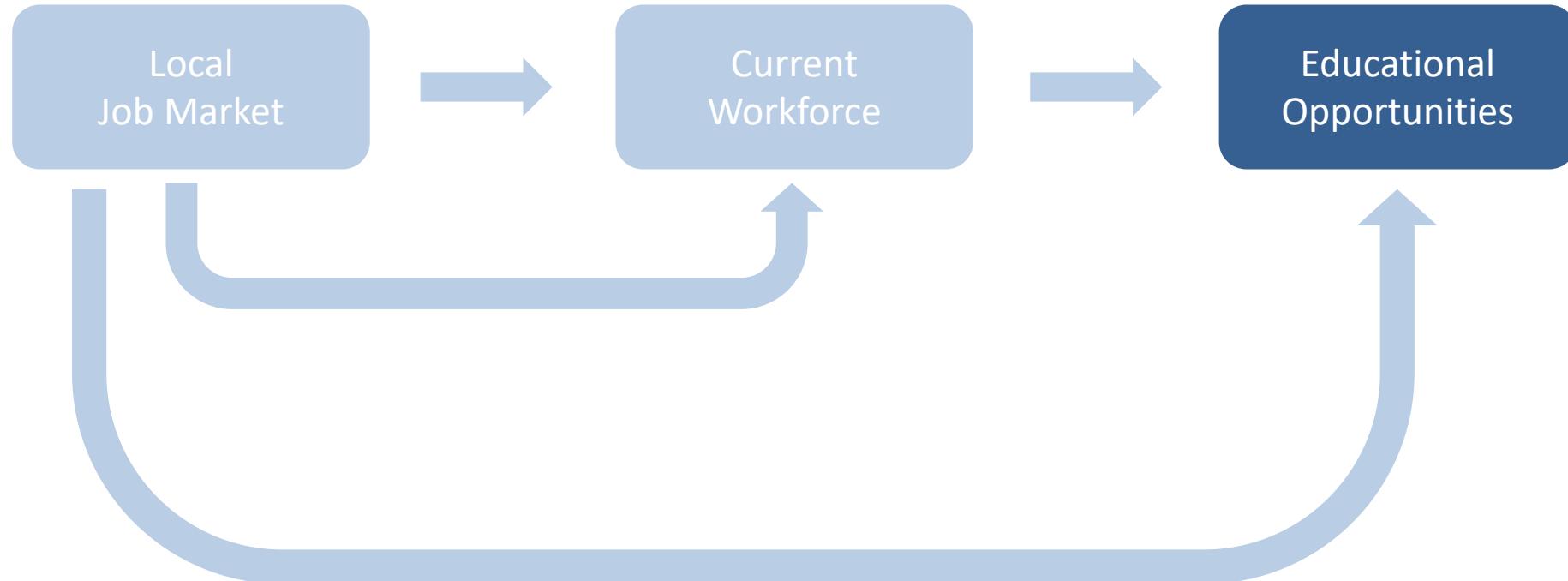
Critical Care Nurses in Blacksburg, VA



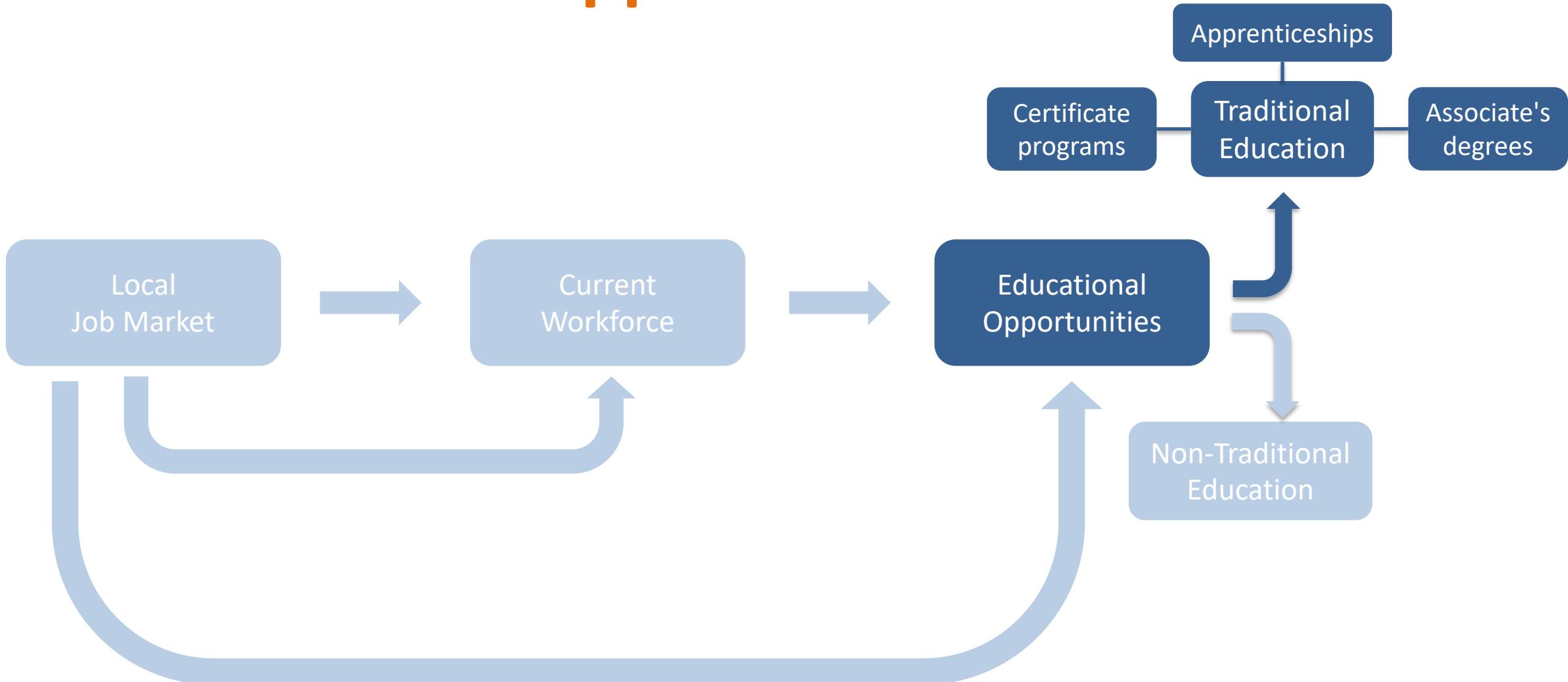
Source: Burning Glass Technologies

# Next Steps: Investigating Local Educational Opportunities

Where can job seekers train for a position in the STW?



# Next Steps: Investigating Local Educational Opportunities



# Critical Care Nurse Certifications

## Critical Care Nurse Certification (CCRN)

- American Association of Critical-Care Nurses
- Must be a Registered Nurse (RN)
- Must be in direct care of acutely/critically ill patients for designated years and hours
- Take exam (Adult, Pediatric, Neonatal)
- Cost: \$239, \$344

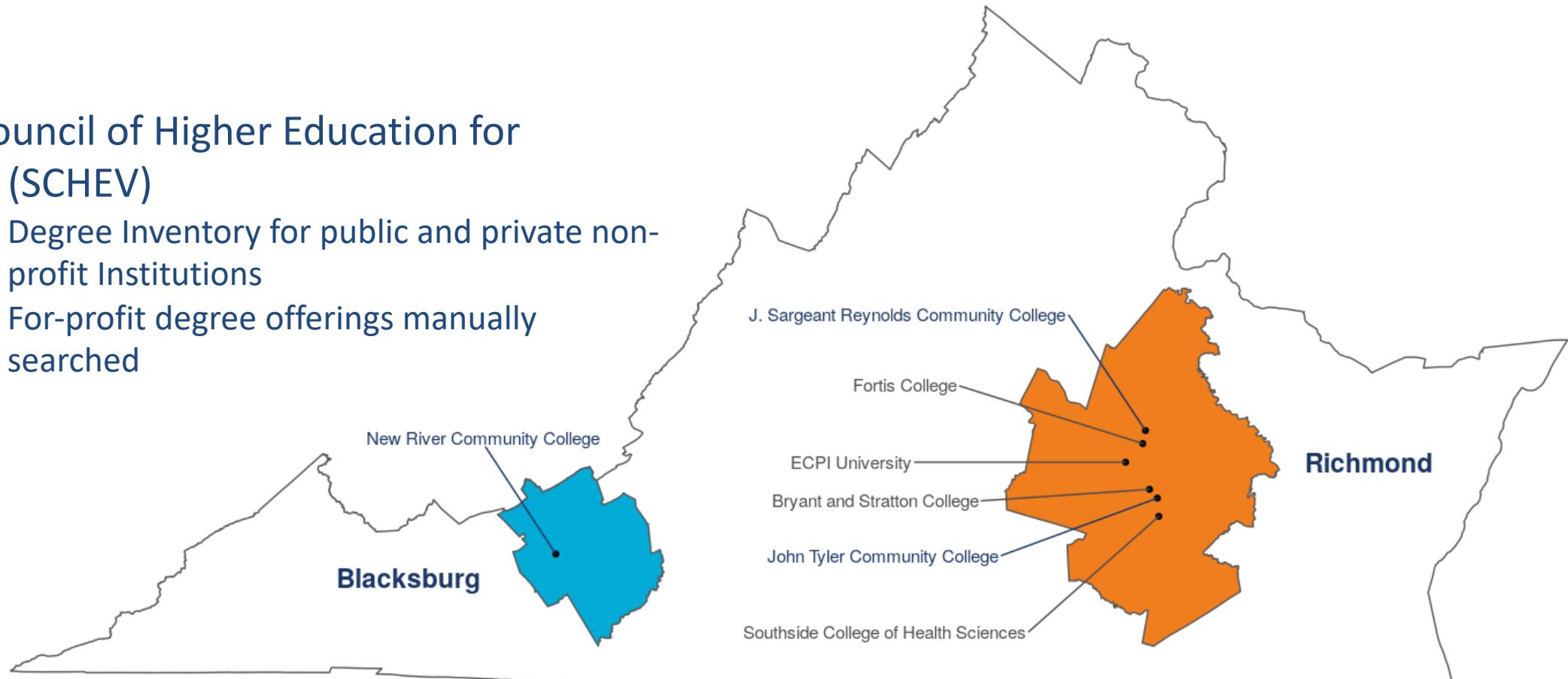
## Neonatal Intensive Care Nursing (RNC-NIC)

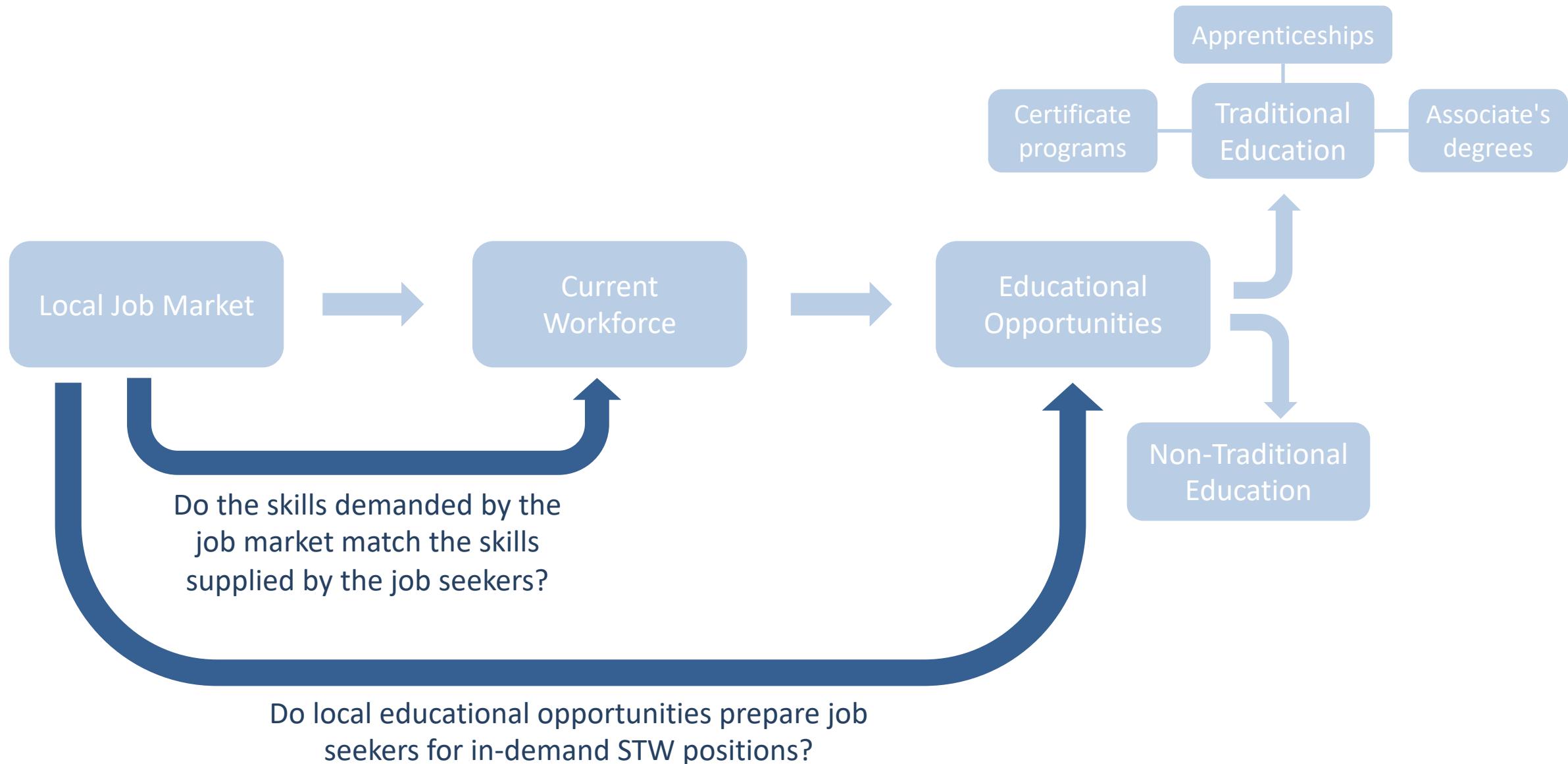
- National Certification Corporation
- Must be a Registered Nurse (RN)
- Must have Neonatal Intensive experience (direct patient care, education, administration, or research) for designated years and hours
- Take exam
- Cost: \$325

# Associate's Degree in Nursing Programs

State Council of Higher Education for Virginia (SCHEV)

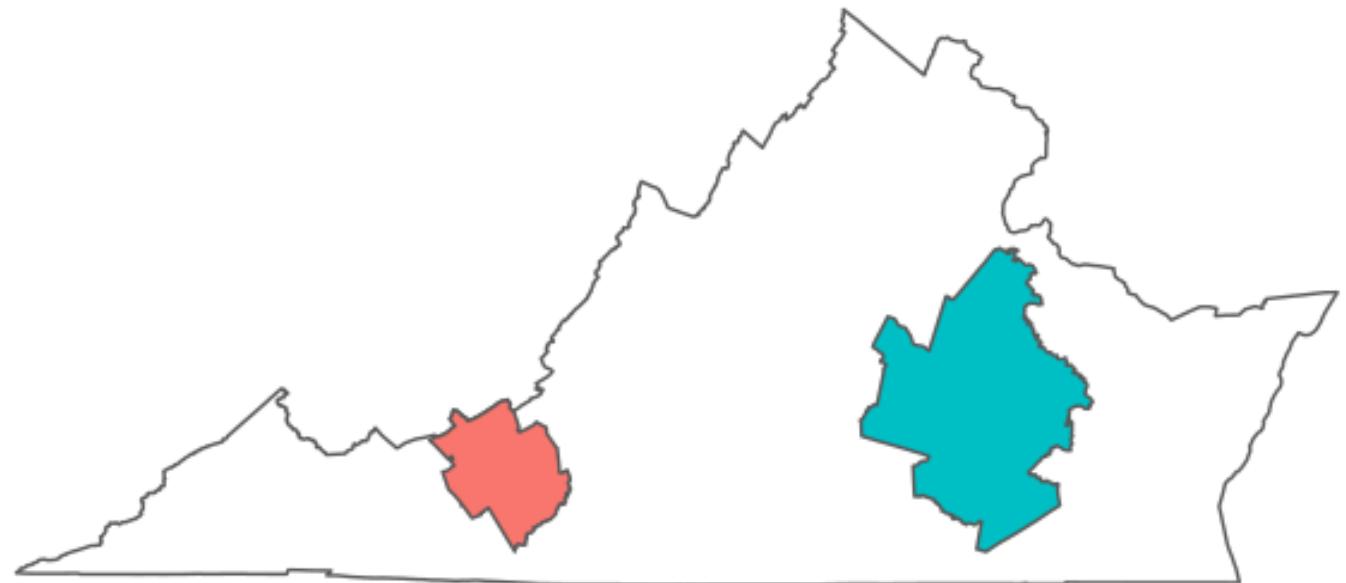
- Degree Inventory for public and private non-profit Institutions
- For-profit degree offerings manually searched





# Broad Conclusions

- We have developed a match metric for skill supply and demand
- There is an undersupply of resumes that match job ads in Critical Care Nursing
  - Skills needed are different in different MSAs
- Both MSAs and surrounding areas have educational opportunities to become a Registered Nurse

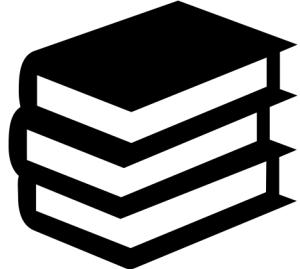


# Next Steps

- Complete analysis for entire state and multiple careers
- Link with the BGT education and credential data to compare candidates with different levels of education
- Find a repeatable method for exploring certifications and non-traditional educational pathways
- Explore the pathways of current skilled technical workers in resumes



# Features of the Job Ad Dataset



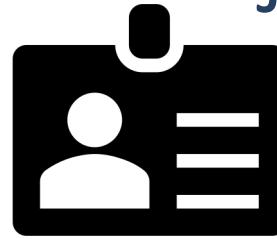
## Desired Credentials

- Degree, Min & Max
- Experience, Min & Max



## Desired Skills

- BGT skill hierarchy, Clusters & Cluster Families
- Highly Cleaned
- BGT Indicators for Baseline, Specialized, Software skills



## Job Details:

- MSA
- O\*NET code
- Date posted
- Salary
- Employer
- Career and Job Type
- Hours

# Finding A Probable STW: Education Level

## Education

- Non-homogenous data
- Multiple degrees per entry,  
skewed distribution
- "Some college"

# Finding A Probable STW: Education Level

## Cleaning

- Institution:
  - High schools and military schools
  - Virginia community colleges
  - Technical and vocational schools
- Degree type:
  - GED
  - Associates of multiple kinds
- Major or degree type:
  - "Some college"
  - "Coursework"

# Finding A Probable STW: Education Level

## Cleaning

- Institution:
  - High schools and military schools
  - Virginia community colleges
  - Technical and vocational schools
- Degree type:
  - GED
  - Associates of multiple kinds
- Major or degree type:
  - "Some college"
  - "Coursework"

Increased maximum education level by 11% to 79%

# Finding A Probable STW: Education Level

- Education threshold:
  - Less than an Associate's
  - No education listed
  - Some college excluded
- New variable: "Has Bachelor's"

# Features of the Resume Dataset



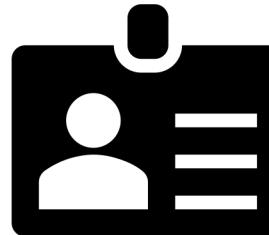
Education/  
Certifications:

- Institution
- Degree Level
- Date
- Major



Skills:

- Clusters
- Cluster Families
- Highly Cleaned



Job History:

- Employer
- Dates
- Position title



Personal Information:

- Number of degrees
- Candidate Location:  
city, state, county,  
zip-code, MSA

# Thank You!

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# Extra Slides

# Summary: Resume Data Pipeline

Candidate Information (Resume) Data Set

BGT Resumes  
2016-2018  
USA Candidate Data Sets

BGT Resumes  
2016-2018  
USA Skill Data Sets

from over  
2200  
candidate  
zip files  
select  
candidates  
in VA

2016-2018  
VA Candidate  
Information  
Data Set  
(N=####)

Keep Candidate Resumes:  
>In MSAs 40060 & 13980  
>Keep only those resumes that  
do not have a data in 2018

2016-2017  
VA Reduced  
Candidate  
Information  
Data Set  
(N=####)

from over  
2200 skill  
zip files  
select  
candidates  
in VA

2016-2018  
VA Skills  
Data Set  
(N=####)

Merge  
Reduced  
Candidate  
Information  
and Skills  
Data Sets  
by  
Resume ID

**+** Add a variable for Bachelors and no Bachelors degree.  
The resume education data table contains a field, "degree-level," that provides the number of years of study for each degree (e.g. high school is equivalent to 12). This field was left blank; however, using only the degree-level were able to find the maximum years of study for job candidates. To classify a larger portion of the we performed several exploratory analyses to increase the classification rate. We checked the related fields, "institution name", "major", and "degree type", for information indicative of the degree-level. We used the following criteria to guide our classification.  
a. Virginia's Community Colleges only grant associates degrees (<https://courses.vccs.edu/programs>).  
b. Trade schools (including culinary schools, cosmetology colleges, and other vocational trainings) do not grant bachelor's degrees.  
c. High schools and GED were determined to be non-bachelors.  
d. Wording that indicated partial college, such as "some college" or "course-work in" were determined to be non-bachelors.  
e. Other associate degrees were found by searching for variations of the "associates" and acronyms like "AA" and "AAS" in the degree type field. By using these search criteria and aggregating our results, we increased our categorization rate by 11%, identifying the maximum education level for 79% of resumes.

2016-2017  
VA Candidates +  
Skills + Education  
Merged Data Set  
(N = ####)

from over  
2200  
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zip files  
select  
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in VA and  
merge with  
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and skills

BGT Resumes  
2016-2018  
USA Education Data Sets

Exploratory Data Analysis

## Job Information Data Set

# Summary: Job-Ads Data Pipeline

BGT Job-ads  
2016-2017  
USA Job Information Data Sets

BGT Job-ads  
2016-2017  
USA Skill Data Sets

from 24 job information data sets select ads in VA

2016-2017 VA Job Information Data Set (N=#####)

Keep Jobs Ads:  
>in MSAs 40060 & 13980  
>with an education requirement of ≤ 14 years or no education  
>with O\*NET codes 29-1141.03 and 49-9071.00

2016-2017 VA Reduced Job Information Data Set (N=#####)

from 24 skills data sets select ads in VA

2016-2017 VA Skills Data Set (N=#####)

**Add a variable for hard and soft skills.** A "soft skill" is either personality-based, primarily used to interact with coworkers, or a general way of approaching a problem. Oral communication, teamwork, and creativity are soft skills. A "skill" requires domain-specific knowledge or can be measured and evaluated. Typing, Microsoft Excel, and financial accounting are hard skills. Five researchers manually identified each skill based on the above definition. Their results were then aggregated and used to create a skill type variable.



2016-2017 VA Job Information + Skills Merged Data Set (N = #####)

# Ads for Critical Care Nurses in Richmond and Blacksburg

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205,285

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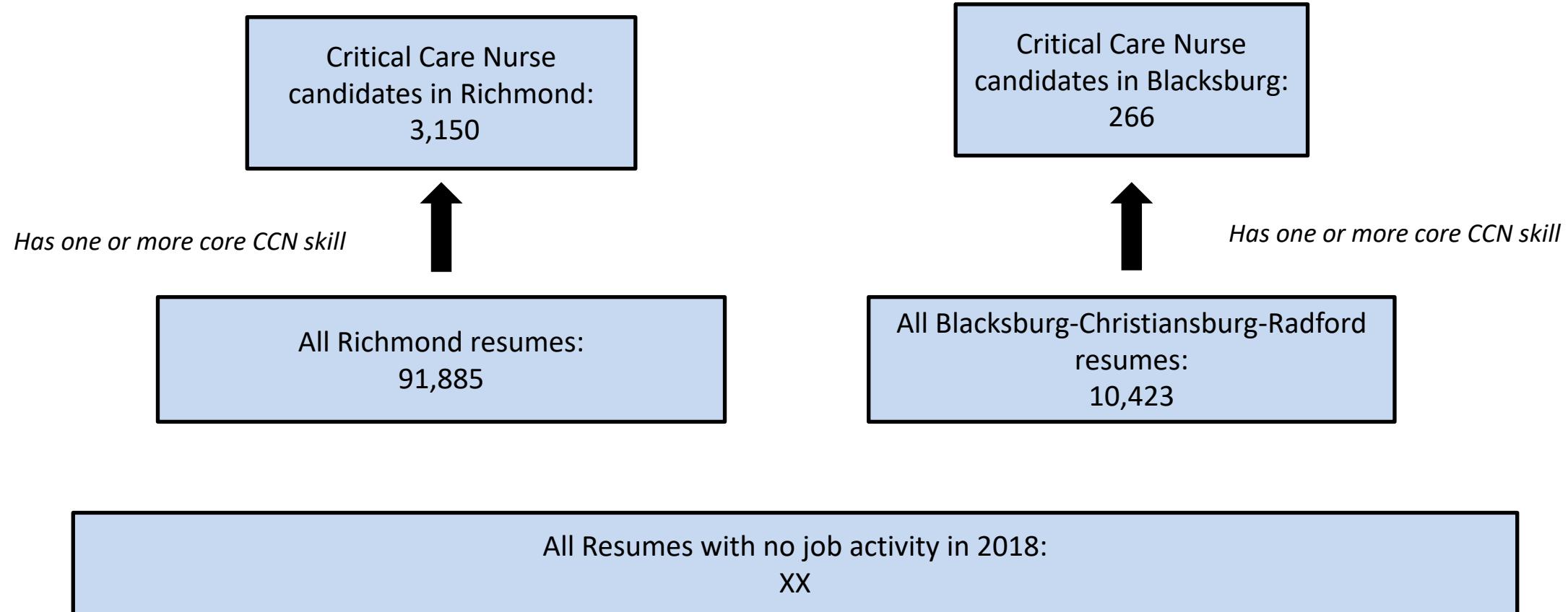
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Critical Care Nurse  
candidates in Richmond:  
3,150

Critical Care Nurse  
candidates in Blacksburg:  
266



All Resumes with no job activity in 2018:  
XX