Trajectories in ADL disability among China’s oldest-old

Zachary Zimmer (University of Utah)
Daniel S. Nagin (Carnegie Mellon)
Linda G. Martin (RAND)
Bobby L. Jones (Carnegie Mellon)
Introduction

* Disability a dynamic process

* Much research examines disability transitions (2 points in time)

* Transitions useful for determining ‘Active Life Expectancies’

* Transitions inadequate for comprehending the total dynamic

* Need to move to examining disability trajectories

* Examining disability trajectories challenging:
  a) Requires longitudinal data
  b) Requires different methodological approaches
Previous studies of disability trajectories

* Few

* Some rely on subjective groupings

* Tend to stratify analyses by survivor/decedents
Current study

* Investigate disability trajectories among the oldest-old in China

* China important setting due to rapid aging of its population

* Oldest-old (80+) interesting because changes likely to occur over short periods of time

* Application of group-based trajectory modeling using software developed by co-authors (Nagin and Jones)

* Identify common trajectories and examine characteristics of people within trajectory groups
Dataset

• Chinese Longitudinal Healthy Longevity Survey
• Conducted in 22 Chinese provinces (of 34 provincial-level administrative units in China)
• Age 80 to 105 at baseline (N=8805)
• Oversampling at oldest ages
• Results weighted
Study sample:

* Aged 80 to 99
* Not lost to follow-up
* Full disability information
Measuring disability

Disability defined as number of ADL limitations from the following list:

1. Bathing
2. Moving inside the house
3. Feeding
4. Dressing
5. Using toilet
Distribution of number of limitations by wave

Wave 1 | Wave 2 | Wave 3 | Wave 4
---|---|---|---
None |                |                |                
1 |                |                |                
2 |                |                |                
3 |                |                |                
4 |                |                |                
5 |                |                |                

Percent
Mean number ADL limitations and mean age by wave

![Graph showing the mean number of ADL limitations and mean age by wave.](graph.png)
Examining disability trajectories

A disability trajectory is a pathway that describes the number of ADL limitations reported by individuals as they age from wave 1 to wave 4 for survivors or from wave 1 to death for decedents.

Example:

This person experiences rising levels of disability.

This person dies after experiencing mild disability.

This person remains disability-free.
Distribution for most common pathways (0.5%+) among survivors (N=946)

<table>
<thead>
<tr>
<th>wave 1</th>
<th>wave 2</th>
<th>wave 3</th>
<th>wave 4</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>56.7</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>7.1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>2.9</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2.8</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2.2</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1.9</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1.9</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1.6</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1.4</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>1.3</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0.8</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.8</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>0.6</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0.5</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0.5</td>
</tr>
</tbody>
</table>

TOTAL NUMBER POSSIBLE PATHWAYS = 1,296
### Distribution for most common pathways (0.8%+) among decedents (N=4,112)

<table>
<thead>
<tr>
<th>wave 1</th>
<th>wave 2</th>
<th>wave 3</th>
<th>wave 4</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>died</td>
<td>---</td>
<td>---</td>
<td>27.1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>died</td>
<td>---</td>
<td>17.4</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>died</td>
<td>16.9</td>
</tr>
<tr>
<td>1</td>
<td>died</td>
<td>---</td>
<td>---</td>
<td>3.6</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>died</td>
<td>2.8</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>died</td>
<td>---</td>
<td>2.7</td>
</tr>
<tr>
<td>5</td>
<td>died</td>
<td>---</td>
<td>---</td>
<td>2.7</td>
</tr>
<tr>
<td>2</td>
<td>died</td>
<td>---</td>
<td>---</td>
<td>1.8</td>
</tr>
<tr>
<td>0</td>
<td>5</td>
<td>died</td>
<td>---</td>
<td>1.6</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>5</td>
<td>died</td>
<td>1.3</td>
</tr>
<tr>
<td>0</td>
<td>4</td>
<td>died</td>
<td>---</td>
<td>1.2</td>
</tr>
<tr>
<td>4</td>
<td>died</td>
<td>---</td>
<td>---</td>
<td>1.2</td>
</tr>
<tr>
<td>3</td>
<td>died</td>
<td>---</td>
<td>---</td>
<td>1.1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>2</td>
<td>died</td>
<td>1.1</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>died</td>
<td>0.9</td>
</tr>
<tr>
<td>0</td>
<td>2</td>
<td>died</td>
<td>---</td>
<td>0.9</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>4</td>
<td>died</td>
<td>0.9</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>3</td>
<td>died</td>
<td>0.8</td>
</tr>
</tbody>
</table>

**TOTAL NUMBER POSSIBLE PATHWAYS = 258**
Challenges

* On average, number ADLs increase over time

* Not everyone is ‘average’ - people experience different individual trajectories

* In total, 1,554 possible individual trajectories

* Number of possible trajectories in a dataset shrink or grow depending on number of states being monitored and waves

* Goal of modeling to identify groups of people that follow distinctive ADL patterns
Group-based modeling

* ‘Group-based modeling’ designed to identify clusters of individuals following approximately the same trajectory as they age

* Technique specialized application of finite mixture modeling

* Software a modification of PROC TRAJ (developed by co-authors Nagin and Jones)

* Basic software downloadable at: www.andrew.cmu.edu/user/bjones/index.htm
Groups estimated using a likelihood function

\[ P(Y_i) = \sum_j \pi_j(x_i) P^j(Y_i) \]

\( P^j(Y_i) \) = probability of \( Y_i \) given membership in group \( j \)

\( \pi_j \) = probability of membership in group \( j \)

\[ \pi_j(x_i) = \frac{e^{x_i \theta_j}}{\sum e^{x_i \theta_j}} \]

\[ L = \prod_{i=1}^{N} P(Y_i) \]
Predicted number ADLs estimated using a zero-inflated Poisson model for counts

\[ p(x) = \begin{cases} 
0 & \text{with probability } \rho \\
\text{Poisson } (\lambda) \text{ with probability } 1 - \rho 
\end{cases} \]

\[ \ln(\lambda) = \beta_0 + \beta_1 \text{age} + \beta_2 \text{age}^2 + \beta_3 \text{age}^3 \]

\[ \rho = \frac{e^{\alpha_0 + \alpha_1 \text{age} + \alpha_2 \text{age}^2 + \alpha_3 \text{age}^3}}{1 + e^{\alpha_0 + \alpha_1 \text{age} + \alpha_2 \text{age}^2 + \alpha_3 \text{age}^3}} \]
Outputs for each ADL trajectory group

Number of distinct trajectories that define the expected number of ADLs as a function of age

Proportion of the sampled population following each trajectory

Probability of loss due to death by age for each group (latest innovation)
Key references


Predicted trajectories - Females

Group 1: 36.2%
Predicted trajectories - Females

- Group 1: 36.2%
- Group 2: 34.3%
- Group 3: 18.2%
Predicted trajectories - Females

- **Group 1:** 36.2%
- **Group 2:** 34.3%
- **Group 3:** 18.2%
- **Group 4:** 11.3%
Predicted trajectories and probability of dying - Females

Predicted number ADL limitations

Predicted probability of dying

<table>
<thead>
<tr>
<th>Age</th>
<th>Number</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>81</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>83</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>85</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>87</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>89</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>91</td>
<td>3.0</td>
<td>0.6</td>
</tr>
<tr>
<td>93</td>
<td>4.0</td>
<td>0.7</td>
</tr>
<tr>
<td>95</td>
<td>5.0</td>
<td>0.8</td>
</tr>
<tr>
<td>97</td>
<td>5.0</td>
<td>0.9</td>
</tr>
<tr>
<td>99</td>
<td>5.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Raw data points for females in Group 3
Individual trajectories for females in Group 3
Predicted trajectory for females in Group 3
Predicted trajectory for females in Group 3
Predicted trajectory for females in Group 3 and probability of dying
Predicted trajectories - Males

Group 1: 42.3%
Group 2: 30.8%
Group 3: 21.8%
Group 4: 5.1%
Predicted trajectories and probability of dying - Males

Predicted number ADL limitations

Predicted probability of dying

Age

Number

Probability

81 83 85 87 89 91 93 95 97 99

0 1 2 3 4 5

0 0.1 0.2 0.3 0.4 0.5
Comparing predicted trajectories

Females

Males

Age

Number

Females

Males
Selected characteristics of trajectory groups – males

<table>
<thead>
<tr>
<th>Age</th>
<th>Probability</th>
<th>Percent urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>81</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>83</td>
<td>0.1</td>
<td>30</td>
</tr>
<tr>
<td>85</td>
<td>0.2</td>
<td>31</td>
</tr>
<tr>
<td>87</td>
<td>0.3</td>
<td>32</td>
</tr>
<tr>
<td>89</td>
<td>0.4</td>
<td>33</td>
</tr>
<tr>
<td>91</td>
<td>0.5</td>
<td>34</td>
</tr>
<tr>
<td>93</td>
<td>0.6</td>
<td>35</td>
</tr>
<tr>
<td>95</td>
<td>0.7</td>
<td>36</td>
</tr>
<tr>
<td>97</td>
<td>0.8</td>
<td>37</td>
</tr>
<tr>
<td>99</td>
<td>0.9</td>
<td>38</td>
</tr>
</tbody>
</table>
Selected characteristics of trajectory groups – males

![Graph showing age, probability, and percent married for different groups of males.](image)
Selected characteristics of trajectory groups – males

Percent more than primary education

Age

Probability

81 83 85 87 89 91 93 95 97 99
Selected characteristics of trajectory groups – males

![Graph showing probability and percent in agriculture over age]

- Probability
- Percent in agriculture

Age: 81 83 85 87 89 91 93 95 97 99

Selected groups:
- 55%
- 65%
- 45%
- 50%
- 55%

Percent in agriculture chart:
- 60%
- 65%
Selected characteristics of trajectory groups – males

- Percent ever smoked:
  - Current: 5, 80
  - Former: 4, 60

- Age:
  - 81, 83, 85, 87, 89, 91, 93, 95, 97, 99
Disease profiles of trajectory groups – males

- Percent with life threatening condition:
  - 24%
  - 32%
  - 5%
  - 16%
  - 24%
  - 4%
  - 8%
  - 3%

- Percent with debilitating condition:
  - 68%
  - 2%
  - Probability:
    - 54%
    - 61%
    - 1%
    - 47%
    - 0%

- Age:
  - 81, 83, 85, 87, 89, 91, 93, 95, 97, 99

Graphs showing the probability and percent distribution for life threatening and debilitating conditions over different ages.
Summarizing characteristics

For men, those in the ‘higher’ disability trajectory grouping more likely to:

- be urban
- be married
- have high education
- be in non-agricultural professions
- be former smokers
- have life threatening and debilitating conditions

Results (not shown) fairly similar for women
Conclusion

* Group-based modeling using modified PROC TRAJ allows determination of trajectory types

* Analysis suggests several distinct trajectory patterns

* Key differences between men and women:
  - Large group of men remain stable with little disability
  - Small group of men highly disabled throughout
  - All female trajectories include increasing disability

* Trajectories indicating ‘higher’ disability show greater probability of mortality

* Characteristics of ‘high’ disability trajectories include urbanites, married, former smokers, high educated, life threatening and debilitating conditions
Work in progress

* Inclusion of other variables in predicting group membership
* Multivariate analysis of group characteristics
* Sensitivity analysis of loss to follow-up