

Multidimensional Item Response Models in ConQuest

Overview

Dichotomous Data

Between Item Multidimensionality

Within Item Multidimensionality

Polytomous Data

Between Item Multidimensionality

with latent regression

Data

Dichotomous Responses

316 students

24 dichotomized items

Verbal Aggression items

Polytomous Responses

583 students from TIMSS

28 polytomous items (0 to 3)

5 different types of performance tasks

Note: LOTS of missing data (not all students took all items)

Verbal Aggression Data

- Respondents presented with a frustrating scenario
- Asked whether they would
 - *want to* react in verbally aggressive manner, or
 - *actually* react in a verbally aggressive manner
- 4 different settings (store, train, bus, call)
- 3 different forms of verbal aggression (curse, scold, shout)
- 24 items scored dichotomously ($Y_{pi} = 1$ or 0)

Example item: The grocery store closes just as you are about to enter.
Would you want to curse?

Verbal Aggression Item Structure

situation

bus stop	want to curse curse want to scold scold want to shout shout
train	want to curse curse want to scold scold want to shout shout
store	want to curse curse want to scold scold want to shout shout
call	want to curse curse want to scold scold want to shout shout

Verbal Aggression Data Format

Items = Columns

0000000001...2
1234567890...4

Cases = Rows

1 0011101100...0
2 1001110001...1
3 0000000001...1
4 1101001110...0
5 0000011000...1
6 0111001001...0
7 1101111101...0
8 0010101010...0
9 0001100011...0
... ..
316 0101101110...0

Model 1: Between Item MD with Verbal Aggression Data

```
1.  datafile wantdo_cq.dat;
2.  format responses 1-24;
3.  score (0 1) (0 1) ( )
!items(1,3,5,7,9,11,13,15,17,19,21,23);
4.  score (0 1) ( ) (0 1)
!items(2,4,6,8,10,12,14,16,18,20,22,24);
5.  model item;
6.  estimate;
7.  show !estimates=latent,tables=1:2:3:4:9 >> wantdo.shw;
8.  itanal >> wantdo.itn;
9.  show cases !estimates=eap >> wantdo.eap;
10. show cases !estimates=mle >> wantdo.mle;
```

Comments

score

- The command that distinguishes this from unidimensional model
- Syntax: from () to ()

model

- Default model is for dichotomous responses

estimate (default options)

- Integrate using Gauss-Hermite quadrature with 15 nodes per dimension (15x15=225 nodes) [other options: Bock-Aitken quadrature; Monte Carlo]
- Converges when change in EM algorithm is less than .0001
- Max number of EM iterations is 200
- Generate 5 plausible values for each case
- Compute standard errors ignoring covariance between response model parameters (stderr=quick)

ConQuest Iterations

The screenshot shows the output of a ConQuest iteration. Three callout boxes provide context for the data:

- Left box:** "This is the covariance matrix expressed as a correlation matrix" points to the Correlation Estimates table.
- Top-right box:** "This is the current estimate of the covariance matrix for the two dimensions." points to the Variance Estimate table.
- Bottom-right box:** "These are the estimated means for the two dimensions." points to the Beta values.

```
Iteration: 4
ESTEP
Deviance = 13331.03055
Variance Estimate
  1.11840    0.44782
  0.44782    0.77302
Correlation Estimates
  1.00000    0.48163
  0.48163    1.00000
Beta
  0.77560
  1.24405
MSTEP
Maximum change in item parameters is  -0.08096
Maximum change in regression parameters is  0.08714
Maximum change in covariance parameters is  0.08417
Change in the deviance is  110.77262
```

These iterations go by fast in console version of ConQuest!

Possible to save and examine them using graphic user interface version of ConQuest.

ConQuest Output: Summary Table (excerpt)

```
=====
BIMD example want-do
Mon Jul 19 15:08:56
SUMMARY OF THE ESTIMATION
=====
```

```
Estimation method was: Gauss-Hermite Quadrature
with 225 nodes
Assumed population distribution was: Gaussian
Constraint was: DEFAULT
The Data File: wantdo_cq.dat
The format: responses 1-24
The item model: item
Sample size: 316
Final Deviance:          7987.347
Total number of estimated parameters: 27
The number of iterations: 18
Termination criteria: Max iterations=200,
Parameter Change= 0.00010, Deviance Change=
0.00010
Iterations terminated because the deviance
convergence criteria was reached
Number of nodes used when drawing PVs: 2000
Number of nodes used when computing fit: 1000
Number of plausible values to draw: 5
Maximum number of iterations without a deviance
improvement: 20
Maximum number of Newton steps in M-step: 10
```

ConQuest Item Parameter Estimates

BIMD example want-do Mon Jul 19 15:08:56
 TABLES OF RESPONSE MODEL PARAMETER ESTIMATES

```
=====
                                TERM 1: item
-----
```

VARIABLES		WEIGHTED FIT			
item	ESTIMATE	ERROR [^]	MNSQ	CI	T
1	1	-1.066	0.101	0.93 (0.86, 1.14)	-1.0
2	2	-1.920	0.113	0.99 (0.85, 1.15)	-0.1
3	3	-0.389	0.098	1.00 (0.89, 1.11)	-0.0
4	4	-0.992	0.108	0.89 (0.88, 1.12)	-1.8
5	5	0.114	0.097	0.99 (0.89, 1.11)	-0.2
6	6	0.389	0.110	0.99 (0.87, 1.13)	-0.2
7	7	-1.585	0.105	0.97 (0.83, 1.17)	-0.4
8	8	-1.525	0.110	0.95 (0.86, 1.14)	-0.7
9	9	-0.518	0.098	0.97 (0.88, 1.12)	-0.5
10	10	-0.494	0.107	0.95 (0.88, 1.12)	-0.9
11	11	0.198	0.097	0.99 (0.89, 1.11)	-0.2
12	12	1.052	0.115	0.96 (0.84, 1.16)	-0.4
13	13	-0.334	0.098	1.02 (0.89, 1.11)	0.3
14	14	-0.324	0.107	1.11 (0.88, 1.12)	1.7
15	15	0.912	0.099	0.95 (0.88, 1.12)	-0.8
16	16	1.075	0.115	1.13 (0.84, 1.16)	1.5
17	17	1.770	0.104	1.12 (0.84, 1.16)	1.4
18	18	2.630	0.135	0.99 (0.72, 1.28)	0.0
19	19	-0.916	0.100	1.03 (0.87, 1.13)	0.5
20	20	-1.344	0.109	0.99 (0.87, 1.13)	-0.2
21	21	0.550	0.097	0.95 (0.89, 1.11)	-0.9
22	22	-0.142	0.107	1.03 (0.88, 1.12)	0.5
23	23	1.264*	0.330	1.07 (0.87, 1.13)	1.0
24	24	1.595*	0.374	1.05 (0.81, 1.19)	0.5

An asterisk next to a parameter estimate indicates that it is constrained
 Separation Reliability = 0.991
 Chi-square test of param equality = 2198.988, df = 22, Sig Level = 0.00
 ^ Quick standard errors have been used

NOTE: The column for unweighted fit has been omitted to save space

ConQuest Population Parameter Estimates

```
=====
BIMD example want-do                               Mon Jul 19 15:08:56
TABLES OF POPULATION MODEL PARAMETER ESTIMATES
=====
REGRESSION COEFFICIENTS
```

Regression Variable	Dimension	
	Dimension 1	Dimension 2
CONSTANT	0.204 (0.082)	-0.582 (0.095)

 An asterisk next to a parameter estimate indicates that it is constrained

```
=====
COVARIANCE/CORRELATION MATRIX
```

Dimension	Dimension	
	1	2
Dimension 1		1.917
Dimension 2	0.776	
Variance	2.133	2.864

 An asterisk next to a parameter estimate indicates that it is constrained
 Values below the diagonal are correlations and values above are covariances

```
=====
```

ConQuest Reliability Estimates

RELIABILITY COEFFICIENTS

Dimension: (Dimension 1)

MLE Person separation RELIABILITY:	Unavailable
WLE Person separation RELIABILITY:	Unavailable
EAP/PV RELIABILITY:	0.780

Dimension: (Dimension 2)

MLE Person separation RELIABILITY:	Unavailable
WLE Person separation RELIABILITY:	Unavailable
EAP/PV RELIABILITY:	0.768

This is a new feature of ConQuest 2.0

ConQuest Item Map

```

=====
BIMD example want-do                               Mon Jul 19 15:08:56
MAP OF LATENT DISTRIBUTIONS AND RESPONSE MODEL PARAMETER ESTIMATES
=====

```

	Dimension	Terms in the Model
	Dimension 1	Dimension 2 +item
6		
5		X
4	X	X
3	XX	X
2	XXXX	XX 18
1	XXXXXXXX	XXXX 24
0	XXXXXXXXXXXXXXXX	XXXXXXXX 15
-1	XXXXXXXXXXXXXXXX	XXXXXXXX 21
-2	XXXXXXXXXXXXXXXX	XXXXXXXX 6
-3	XXXXXXXXXXXXXXXX	XXXXXXXX 5 11
-4	XXXXXXXXXXXXXXXX	XXXXXXXX 13 14 22
-5	XXXXXXXXXXXXXXXX	XXXXXXXX 3 9 10
-6	XXXXXXXXXXXXXXXX	XXXXXXXX 4 19
-7	XXXXXXXXXXXXXXXX	XXXXXXXX 1
-8	XXXXXXXXXXXXXXXX	XXXXXXXX 20
-9	XXXXXXXXXXXXXXXX	XXXXXXXX 7 8
-10	XXXXXXXXXXXXXXXX	XXXXXXXX 2
-11	XXXX	XXXXXXXX
-12	XXXX	XXXXXX
-13	XXX	XXXXXX
-14	X	XXXXXXXX
-15	X	XXXXXX
-16	X	XXXXXX
-17	X	XXXXXX
-18	X	XXXX
-19	X	XXXX
-20	X	XXXX
-21	X	XXXX
-22	X	XXXX
-23	X	XXXX
-24	X	XXXX
-25	X	XXXX
-26	X	XXXX
-27	X	XXXX
-28	X	XXXX
-29	X	XXXX
-30	X	XXXX
-31	X	XXXX
-32	X	XXXX
-33	X	XXXX
-34	X	XXXX
-35	X	XXXX
-36	X	XXXX
-37	X	XXXX
-38	X	XXXX
-39	X	XXXX
-40	X	XXXX
-41	X	XXXX
-42	X	XXXX
-43	X	XXXX
-44	X	XXXX
-45	X	XXXX
-46	X	XXXX
-47	X	XXXX
-48	X	XXXX
-49	X	XXXX
-50	X	XXXX
-51	X	XXXX
-52	X	XXXX
-53	X	XXXX
-54	X	XXXX
-55	X	XXXX
-56	X	XXXX
-57	X	XXXX
-58	X	XXXX
-59	X	XXXX
-60	X	XXXX
-61	X	XXXX
-62	X	XXXX
-63	X	XXXX
-64	X	XXXX
-65	X	XXXX
-66	X	XXXX
-67	X	XXXX
-68	X	XXXX
-69	X	XXXX
-70	X	XXXX
-71	X	XXXX
-72	X	XXXX
-73	X	XXXX
-74	X	XXXX
-75	X	XXXX
-76	X	XXXX
-77	X	XXXX
-78	X	XXXX
-79	X	XXXX
-80	X	XXXX
-81	X	XXXX
-82	X	XXXX
-83	X	XXXX
-84	X	XXXX
-85	X	XXXX
-86	X	XXXX
-87	X	XXXX
-88	X	XXXX
-89	X	XXXX
-90	X	XXXX
-91	X	XXXX
-92	X	XXXX
-93	X	XXXX
-94	X	XXXX
-95	X	XXXX
-96	X	XXXX
-97	X	XXXX
-98	X	XXXX
-99	X	XXXX
-100	X	XXXX

Each 'X' represents 1.2 cases

- Notes:
- 1) Item maps are also provided separately by dimension (new)
 - 2) Latent distributions are not directly comparable

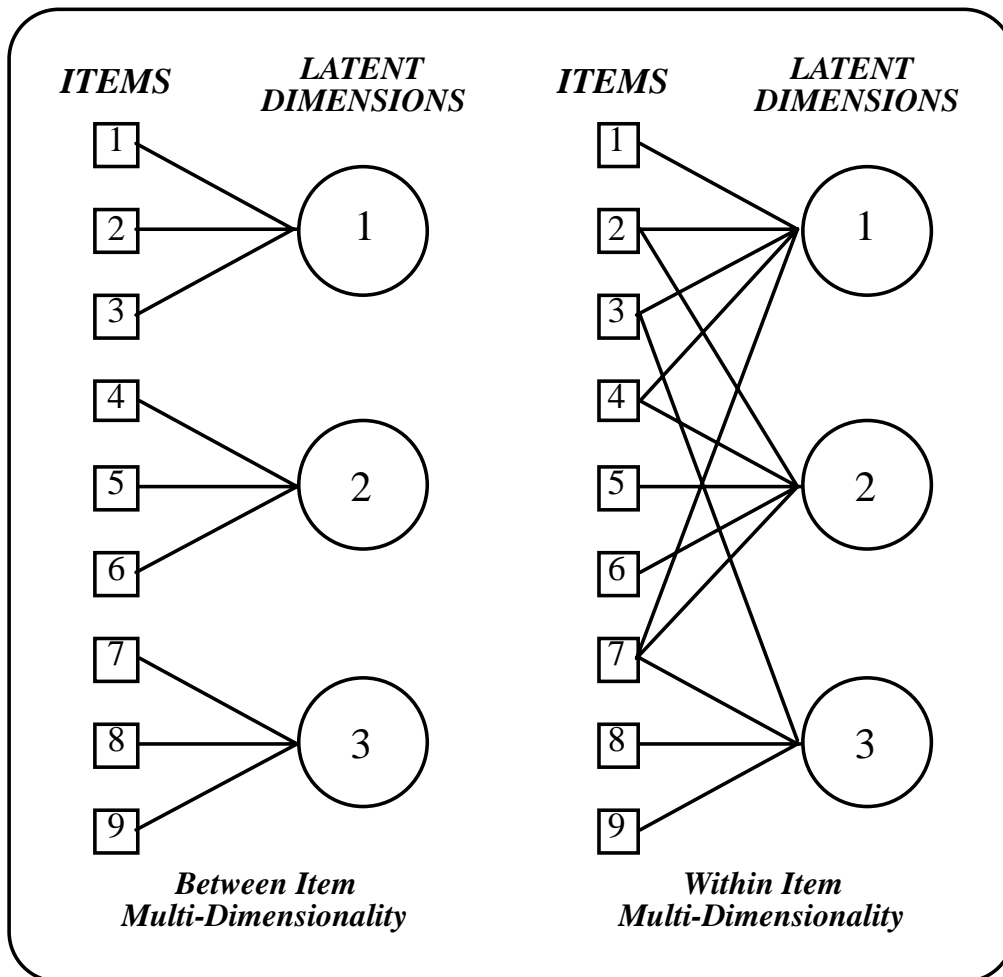
ConQuest Person Estimates (wantdo.eap)

```
1
  1      -0.60  0.23
  2     -1.29 -0.00
  3     -1.80 -1.19
  4     -1.80 -0.82
  5     -0.68  0.67
-1.10341 -0.23860
 0.63549  0.56912
2
  1     -2.86 -2.86
  2     -2.79 -3.41
  3     -2.30 -3.03
  4     -2.46 -2.90
  5     -3.15 -3.10
-2.61175 -3.13107
 0.73681  0.86871
3
  1     -0.13 -1.85
  2      0.89 -0.92
  3      0.27 -1.13
  4     -0.34 -0.90
  5      0.05 -0.63
-0.01549 -0.94880
 0.53907  0.61263
4
  1      0.25 -0.38
  2      0.31  0.13
  3      0.43  1.18
  4      0.69  0.60
  5      1.79  0.24
 0.54700  0.24220
 0.53859  0.60668
```

ConQuest Person Estimates (wantdo.mle)

1	2.0	12	7.0	12	-1.89	0.81	0.42	0.69
2	0.3	12	1.0	12	-4.05	1.85	-2.99	1.09
3	6.0	12	4.0	12	-0.01	0.63	-0.98	0.69
4	7.0	12	7.0	12	0.39	0.64	0.42	0.69
5	5.0	12	5.0	12	-0.42	0.64	-0.51	0.68

BIMD vs. WIMD



The preceding example was of a BIMD model

Verbal Aggression Data using WIMD Model

```
1. datafile wantdo_cq.dat;
2. format responses 1-24;
3. score (0 1) (0 1) ( )
!items(1,3,5,7,9,11,13,15,17);
4. score (0 1) ( ) (0 1)
!items(2,4,6,8,10,12,14,16,18);
5. score (0 1) (0 1) (0 1) !items(19-24);
6. model item;
7. estimate;
8. show !estimates=latent,tables=1:2:3:4:9 >>
wando2.shw;
9. show cases !estimates=eap >> wando2.eap;
10. show cases !estimates=mle >> wando2.mle;
```

Only difference in command file is the additional score statement (5) and naming of output files.

All items related to a frustrating phone call scenario invoke aspects of both want and do dimensions verbal aggression.

Interpretation of item location parameters for items 19-24 is now different (composite location).

BIMD Model with Polytomous Data

```
title Australian Performance Assessment Data;
datafile ex7b.dat;
format    responses 1-28 female 29;
codes     0,1,2,3;
labels << ex7b.nam;
recode (2) (1) !items(9,10);
recode (3) (2) !items(25);
score (0,1,2,3) (0,1,2,3) ( ) ( ) ( ) ( ) ! items (1-
6);
score (0,1,2,3) ( ) (0,1,2,3) ( ) ( ) ( ) ! items (7-
13);
score (0,1,2,3) ( ) ( ) (0,1,2,3) ( ) ( ) ! items
(14-17);
score (0,1,2,3) ( ) ( ) ( ) (0,1,2,3) ( ) ! items
(18-25);
score (0,1,2,3) ( ) ( ) ( ) ( ) (0,1,2,3) ! items
(26-28);
/*regression female;*/
model item+item*step;
set warnings=no,update=yes;
export parameters >>ex7b.prm;
export reg_coefficients >>ex7b.reg;
export covariance >> ex7b.cov;
import init_parameters <<ex7b.prm;
import init_reg_coefficients <<ex7b.reg;
import init_covariance << ex7b.cov;
estimate!method=montecarlo,nodes=2000,conv=.005;
show ! tables=1:2:3:4,estimates=latent>>ex7b.shw;
```

ConQuest Item Parameter Estimates (1)

=====
 Australian Performance Assessment Dat Tue Jul 20 07:14:45
 TABLES OF RESPONSE MODEL PARAMETER ESTIMATES
 =====

TERM 1: item

VARIABLES		WGHTED FIT				
item	ESTIMATE	ERROR	MNSQ	T		
1	bspm11	-1.126	0.132	1.15	1.2	
2	bspm12	0.024	0.128	0.99	-0.0	
3	bspm13	-0.579	0.121	0.87	-1.1	
4	bspm14	0.395	0.104	1.10	1.1	
5	bspm15a	-0.836	0.138	0.88	-1.3	
6	bspm15b	2.122*				
7	bspm21	-2.804	0.114	1.02	0.3	
8	bspm22	0.702	0.080	1.28	2.6	
9	bspm23	-1.426	0.105	1.11	1.1	
10	bspm24	-0.301	0.099	1.05	0.5	
11	bspm25	0.622	0.082	1.10	1.0	
12	bspm26a	1.580	0.074	0.98	-0.1	
13	bspm26b	1.628*				
14	bspm31	-0.034	0.074	1.31	2.6	
15	bspm32	-0.749	0.077	1.21	1.8	
16	bspm33	-0.182	0.074	1.27	2.3	
17	bspm34	0.965*				
18	bspm41	-1.181	0.109	1.05	0.5	
19	bspm42	-0.698	0.093	0.98	-0.2	
20	bspm43	-0.516	0.104	1.31	3.0	
21	bspm44	-1.205	0.110	1.05	0.5	
22	bspm45a	0.221	0.069	0.92	-0.8	
23	bspm45b	0.356	0.111	0.94	-0.6	
24	bspm45c	-0.212	0.083	0.80	-2.3	
25	bspm46	3.235*				
26	bspm51	-0.323	0.066	1.26	2.5	
27	bspm52	-0.245	0.076	0.88	-1.3	
28	bspm53	0.568*				

 An asterisk next to a parameter estimate indicates that it is constrained

Separation Reliability = 0.988

Chi-square test of parameter equality = 2017.628, df = 23, Sig Level = 0.000a

ConQuest Item Parameter Estimates (2)

```
=====
TERM 2: item*step
-----
```

VARIABLES				WGHTED FIT	
item	step	ESTIMATE	ERROR	MNSQ	T
1	bspm11	1	1.131	0.423	0.94 -0.0
3	bspm13	1	1.931	0.510	0.95 0.0
4	bspm14	1	-0.727	0.165	1.06 0.9
7	bspm21	2	1.259	0.589	0.95 0.1
8	bspm22	1	-0.042	0.168	0.97 -0.4
11	bspm25	1	-0.433	0.157	0.99 -0.2
12	bspm26a	1	0.139	0.170	1.10 1.5
12	bspm26a	2	-1.842	0.177	1.08 1.1
13	bspm26b	1	-0.179	0.177	0.99 -0.1
14	bspm31	1	0.047	0.194	0.93 -0.6
15	bspm32	1	-0.114	0.209	0.91 -0.7
16	bspm33	1	0.317	0.214	0.93 -0.5
17	bspm34	1	-0.095	0.161	1.04 0.7
17	bspm34	2	-0.195	0.188	0.96 -0.3
18	bspm41	1	1.031	0.257	0.96 -0.1
19	bspm42	1	2.215	0.386	1.01 0.1
20	bspm43	1	-0.684	0.149	1.08 2.4
21	bspm44	1	0.672	0.225	0.99 0.0
22	bspm45a	1	1.704	0.184	0.97 -0.3
22	bspm45a	2	-1.124	0.208	0.96 -0.3
23	bspm45b	1	-1.207	0.147	0.94 -2.2
24	bspm45c	1	-0.794	0.150	0.93 -1.9
24	bspm45c	2	-0.102	0.155	0.95 -0.9
25	bspm46	1	-0.000	0.330	1.00 0.1
26	bspm51	1	0.022	0.152	1.03 0.8
26	bspm51	2	-0.551	0.165	1.04 0.5
27	bspm52	1	-0.361	0.156	1.00 0.0
28	bspm53	1	0.505	0.196	1.03 0.3

An asterisk next to a parameter estimate indicates that it is constrained

=====

ConQuest Population Parameter Estimates

=====
Australian Performance Assessment Data
07:14:45

Tue Jul 20

TABLES OF POPULATION MODEL PARAMETER ESTIMATES
=====

REGRESSION COEFFICIENTS

Dimension

CONSTANT

1	1.677 (0.055)
2	0.543 (0.045)
3	1.164 (0.060)
4	0.112 (0.034)
5	-0.028 (0.046)

=====
COVARIANCE/CORRELATION MATRIX

Dimension	Dimension				
	1	2	3	4	5
1		0.790	0.785	0.438	0.229
2	0.550		0.849	0.372	0.282
3	0.407	0.541		0.726	0.844
4	0.408	0.426	0.619		0.456
5	0.156	0.236	0.525	0.510	
Variance	1.766	1.169	2.108	0.652	1.225

Values below the diagonal are correlations and values above are
covariances
=====

ConQuest Item Map

Australian Performance Assessment Data

Tue Jul 20 07:14:45

MAP OF LATENT DISTRIBUTIONS AND RESPONSE MODEL PARAMETER ESTIMATES

```

=====
Dimension                                     Terms in the Model Statement
-----
      1      2      3      4      5      +item      +item*step
-----
6
5
4      X      X      X      X
      X      X      X      X
      XX     XX     X      X
      XX     X      X      X
      XXX    X      X      X
      XXX    XX     XX     25
3      XXXX   XXX    XXX     X
      XXXXX  X      XXX     X
      XXXXX  XX     XXXX    X
      XXXX   X      XXX     X
2      XXXXX  XXX    XXXXX   X      X      6      19.1
      XXXXXX XXX    XXXXXX  X      XX     3.1
      XXXXXX XXXXXX XXXXXX  XX     XX    12 13  22.1
      XXXXXX XXXXXX XXXXXX  XXX    XXX   7.2
1      XXXXXX XXXXXX XXXXXX  XXXXXX XXXX  XXXX  1.1 18.1
      XXXXXX XXXXXX XXX    XXXXXX  XXXXX  17
      XXXX   XXXXXX  XXXXXX  XXXXXX  XXXXXX  8 11  21.1
      XXXX   XXXXXX  XXXXXX  XXXXXX  XXXXXX  28  28.1
      XXXX   XXXXXX  XXXXXXXXXXXX XXXXXXXXXXX 4 22  16.1
      XXXX   XXXXXX  XXXXXX  XXXXXXXXXXX XXXXXXXXXXX 2  12.1 14.1 26.1
0      XX     XXXXXX  XXXX   XXXXXXXXXXX XXXXXX  14 16  8.1 13.1 15.1 17.1 24.2
      XX     XXXXXX  XXX   XXXXXXXXXXX XXXXXX  10 24  17.2 25.1 27.1
      XX     XXXXXX  XX    XXXXXXXXXXX XXXXXX  20  11.1 26.2
      X      XXXX   XXX   XXXXXX  XXXXXX  3 15  4.1 20.1
      X      XXXX   XX    XXXXXX  XXXXXX  5  24.1
-1     XX     X      XXX   XXXXXX  1  22.2
      X      XX    XX    XXX   XXXX  18 21  23.1
      X      XX    XX    XXX   XXX  9
      X      X      X      XXX   XXX  12.2
-2     X      X      X      X      X
      X      X      X      X      X
-3     X      X      X      X      X
-4
=====

```

Each 'X' represents 5.7 cases