Online-Appendix

Adherence to Recommended Care Guidelines for Preschool-Aged Children Diagnosed with ADHD in Medicaid

Data Processing and Analysis

Data Query

Two of the data files, for outpatient services (OT) and drug services (RX), consisted of identifiable patient-level claims data with information on service utilization and expenditures for all Medicaid-enrolled beneficiaries. These two files were used to both identify which children met the case definition for having ADHD and to identify the relevant encounters for patients diagnosed with ADHD. We also extracted data from the personal summary (PS) Medicaid Analytic eXtract (MAX) files to acquire patient-level demographic and enrollment characteristics. The research in this paper complies with protocols approved by the Centers for Medicare and Medicaid Services (CMS).

Included for each claim from the OT data file were indicators for date of service, the identification number of each patient, up to 2 ICD-9 codes for diagnosis, the procedure code, and the type and place of service. Included for each claim from RX were indicators specifying the date of service, the identification number of each patient, and the national drug code (NDC). Only RX claims whose patient identification number corresponded to a patient identification number from an OT claim and whose NDC corresponded to a medication FDA-approved to treat ADHD (amphetamine and mixed amphetamine salts, atomoxetine, clonidine, dextroamphetamine, dexmethylphenidate, guanfacine, lisdexamfetamine, and methylphenidate) were extracted. Multiple non-RX claims in a single day for the same patient were considered as one visit. Claims for consecutive days at a mental health facility were considered as one visit.

Study Population

In this supplemental section we provide details on the derivation of the study population.

The states and years we extracted MAX data are:

• States: Alabama (AL), Georgia (GA), Florida (FL), Mississippi (MS), Louisiana (LA), North Carolina (NC) and South Carolina (SC); and

• Years: 2005–2012.

We queried the OT MAX Data for the following population:

• Patients with claims with either diagnosis code 1 (DIAG_CD_1) or diagnosis code 2 (DIAG_CD_2) in this list: 314, 31400, 31401, 3141, 3142, 3148, 3149; and

• Children aged 2 to 5 years old[1].

We queried the RX MAX Data for the following set of claims:

• Claims for children aged 2 to 5 years old; and

• Claims with a national drug code (NDC) for a medication FDA-approved to treat ADHD.

In order to obtain the population of patients with a first ADHD diagnosis within the study time span we reduced the population as follows:

• Exclude patients who had an ADHD-related claim during the initial 6 months of their Medicaid enrollment, more specifically, we used a wash out period of 6 months prior to the initial ADHD claim observed in the MAX data;

• Exclude any patient whose first claim was for a medication with an indication to treat ADHD[2];

• Exclude any patient who was not Medicaid eligible for 6 months prior to the initial claim with an ADHD diagnosis code;

• Exclude any patient who did not have at least two claims with an ADHD diagnosis code that occurred on different dates;

• Remove all duplicate claims[3];

• Create dominant event type for claims where the patient identification number and service date are the same, but event type is different within the same day, using this hierarchy: ER > PS > MHF > PO > OP[4];

• Combine consecutive MHF claims for a patient into one event[5]; and

[1] If a patient is in the study population but some of his/her claims are for age older than 5 years, we did not include these claims in the analysis.
[2] If a patient's first event is medication, it implies that we do not have the initial diagnosis for the patient.
[3] This is for the claims that had the same MSIS_ID, SRVC_BGN_DT, and Event type (Including RX claims).
[4] Exclude RX events from this step because a patient can pick up medication on the same day they see a provider. This means that if two different claims were for the same patient on the same day and both events are different, take the two claims as a single event by deleting the less important event according to the defined hierarchy, where ER is most important and OP is least important. For example, if one of the claims was ER and the other was PO, discard the claim for PO.

• Exclude all RX claims associated with patients who were not in the identified population of children with ADHD after the population had been reduced using the steps above.

Provider/Event Classification

For the provider/event classification, the relevant MAX data criteria from the outpatient services file (OT) were the procedure code (PRCDR_CD), the place of service code (PLC_OF_SRVC_CD), and the type of service code (MSIS_TOS).

We created **six** event types for ADHD: psychological services (PS), emergency room (ER), mental health facility (MHF), physician's office visit (PO), other practitioner encounter (OP), and medication filled (RX). All event types except RX were required to have an ADHD diagnosis code included on the claim.

Psychological services (PS): To be classified as PS, a claim fulfilled both of these criteria:

i. The claim's procedure code was one of the 177 procedure codes including (1) Current Procedural Terminology (CPT) codes: 90804–90819, 90821–90824, 90826–90829, 90832–90834, 90836–90840, 90845–90847, 90849, 90853, 90857, 99354–99355, and 99510; and (2) Healthcare Common Procedure Coding System (HCPCS) codes: G0410, G0411, H0035–H0037, H2012–H2013, H2017–H2020, S9480, and T1027;

ii. One of the following scenarios must be true:

1. Place of service was in an office (PLC_OF_SRVC = 11) and type of service was physician, other practitioner, or nurse practitioner (MSIS_TOS in [8, 10, 37]);
2. Place of service was a school, an office, a patient's home, an outpatient hospital, a community health center, or unknown (PLC_OF_SRVC in [3, 11, 12, 22, 53, 99]) and type of service was clinic (MSIS_TOS = 12);
3. Place of service was an outpatient hospital (PLC_OF_SRVC = 22) and type of service was physician, other practitioners, or outpatient hospital (MSIS_TOS in [8, 10, 22])

Emergency Room (ER): To be classified as ER, a claim fulfilled this criteria:

i. Place of service was in an inpatient hospital, outpatient hospital, or emergency room (PLC_OF_SRVC in [21, 22, 23]).

Medical Health Facility (MHF): To be classified as MHF, a claim fulfilled this criteria:

i. Place of service was an inpatient psychiatric facility, a psychiatric facility partial hospitalization, or a community mental health center (PLC_OF_SRVC in [51, 52, 53]).

Physician's Office (PO): To be classified as PO, a claim fulfilled these criteria:

i. Place of service was an office, comprehensive inpatient rehabilitation facility, urgent care facility, psychiatric facility (partial hospitalization), or school (PLC_OF_SRVC in [11, 61, 20, 52, 3]);

ii. Type of service was physician (MSIS_TOS = 8); and

[5] This means that if an MSIS_ID had multiple MHF claims in a row where the dates were consecutive (e.g., January 1, January 2, January 3, etc.), then we can assume that the patient was staying at the same mental health facility for several days, and count all of those claims as a single visit to an MHF.

iii. Does not meet the specifications of a psychological services event.

Other Practitioner (OP): To be classified as OP, a claim fulfilled both of these criteria:

i. Place of service was an office (PLC_OF_SRVC_CD = 11);

ii. Type of service was other practitioner or nurse practitioner (MSIS_TOS in [10, 37]); and

iii. Does not meet the specifications of a psychological services event.

Medication Received (RX): To be classified as RX, a claim fulfilled these criteria:

i. Claim was from the RX table for a child aged 2–5 years;

ii. Patient identification number from the claim was in the population of identified patients with ADHD;

iii. The NDC code was for a generic or brand name version of the following medications: amphetamine and mixed amphetamine salts, atomoxetine, clonidine, dextroamphetamine, dexmethylphenidate, guanfacine, lisdexamfetamine, and methylphenidate.

Ecological Factors

For the logistic regression component of this study's analysis, several ecological factors were considered based on the zip code associated with child's Medicaid enrollment. Urbanicity was determined using Rural-Urban Commuting Area (RUCA) codes associated with the patient-level zip code and grouped into three categories: *large urban* (RUCA=1–3), *small urban* (RUCA=4–6), and *rural* (RUCA=7–10). Socioeconomic factors included the percentage of households whose prior year income was below the federal poverty level and the percentage of the adult population with a bachelor's degree. Both factors were extracted from 2010 Census Bureau data at the zip code level[6].

Sequence Clustering Analysis

The main steps in the SCA algorithm were:

1. Initialization Step: Randomly initialized the clusters (profiles) and determined the corresponding transition matrices, T_k, for $k \in (1, \ldots, K)$ or using prior knowledge about the clustering probabilities.
2. Expectation Step: Re-assigned the patient care sequences to the profile with the transition matrix that produced the sequence with the greatest probability.

[6] US Census Bureau, *Demographic Data*. 2010.

3. Maximization Step: Recalculated the transition matrix based on the sequences in each profile.
4. Repeat steps 2 & 3 until convergence; that is, no sequence changes profile membership.

For the initialization step, we used a random initialization across all three clusters with equal probability.

Selecting the Number of Utilization Profiles

In order to determine the optimal number of profiles for the network model, we optimized the trade-off between two measures.

- *Model size* is the number of utilization profiles in the SCA and it is a measure of the model complexity.
- *Variability* measure quantifies both the sparsity and variability within a single utilization profile derived from the SCA. A profile with a high degree of variability will contain multiple provider types and/or a high number of transitions between provider types. The variability measure is a weighted sum of the variances of each binomial edge in the model. We included the probabilities out of the initial node but did not consider the transition probabilities directed to the terminal node as they can be fully determined by the other transition probabilities.

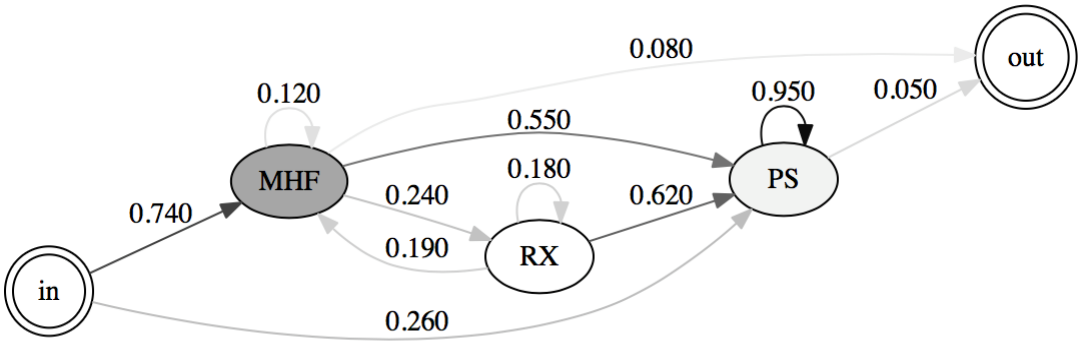
As the number of profiles increases, the variability decreases, and vice versa. A profile with too much variability will not be useful in characterizing a network as it may include many low probability edges. For this reason we desired a low variability value, which can be attained by fitting a large number of utilization profiles. However, it is still important to avoid overfitting. An insignificant decrease in model variability when considering a larger number of profiles suggests that the model can be adequately described with fewer profiles.

We used this approach to select the number of profiles for the set of medical visits in this study and set the maximum number of profiles identified per state at three.

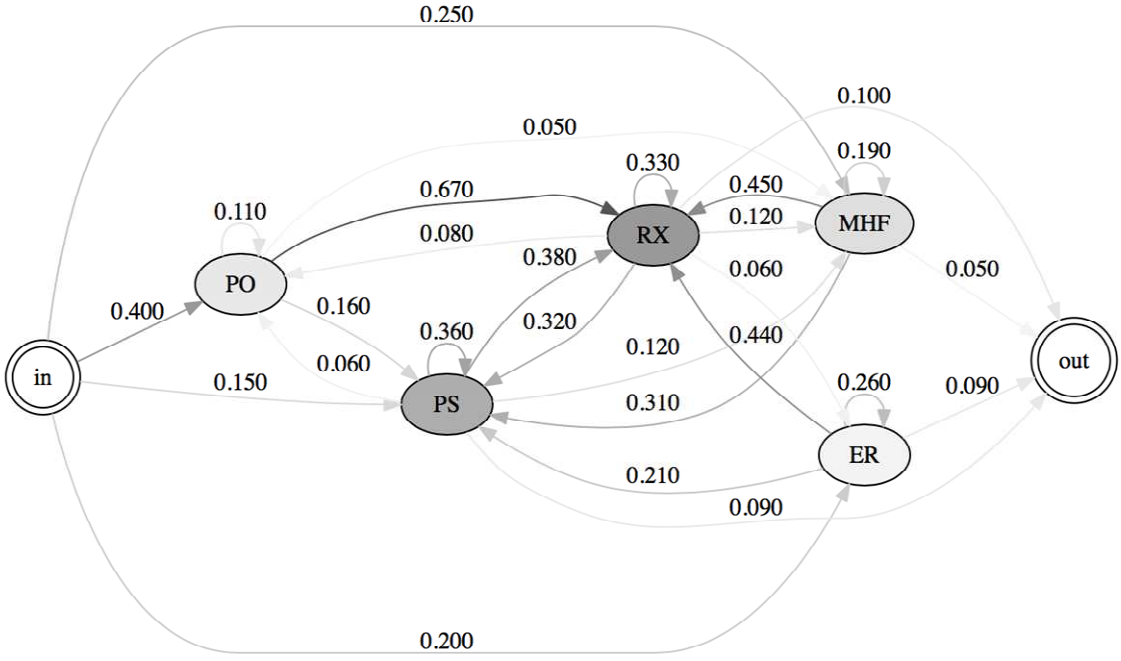
Table A1: *Demographic Characteristics of Children Aged 2–5 Years in Medicaid with Two or More Claims with a Primary Diagnosis of ADHD, 7 states, 2005–2012*

	Alabama n=5,585 %	Florida n=10,932 %	Georgia n=10,164 %	Louisiana n=9,348 %	Mississippi n=3,843 %	North Carolina n=10,020 %	South Carolina n=3,568 %
Sex							
Male	70.8	73.6	71.0	71.9	70.7	73.0	73.6
Female	28.9	26.4	29.0	28.1	29.3	27.0	26.4
Unknown	0.3						
Race							
White	56.9	32.6	48.4	57.1	43.6	54.9	52.5
Black	38.1	24.8	40.4	37.7	48.8	32.4	35.6
Other	5.1	42.7	11.3	5.2	7.7	12.6	12.0
Medicaid Plan Type							
Fee-for-Service	23.5	15.8	7.7	26.8	16.3	24.5	18.1
Other Coverage Type	76.5	84.2	92.4	73.2	83.7	75.5	82.0
Medicaid Basis of Eligibility							
Poverty/Other	88.7	76.0	80.2	85.6	85.6	86.9	84.6
Foster Care	2.0	8.1	9.8	5.3	2.5	4.8	6.4
Disability	9.3	15.9	10.0	9.1	11.9	8.3	9.0
Urbanicity							
Large Urban	62.3	83.3	62.7	66.8	46.0	51.4	71.4
Small Urban	6.8	0.5	15.0	5.4	25.2	13.0	5.5
Rural	30.9	16.3	22.3	27.8	28.8	35.6	23.2

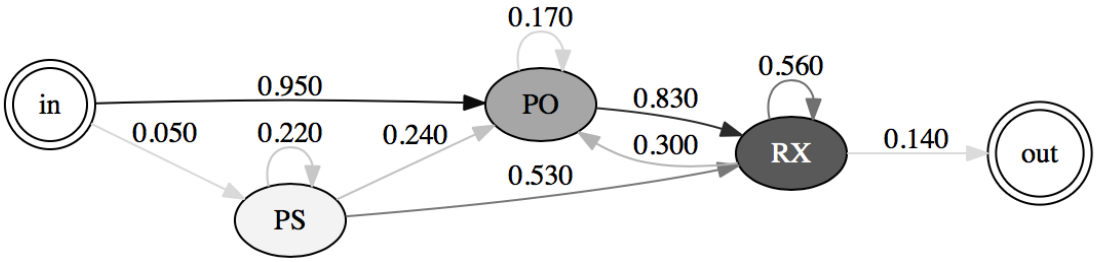
Figure A1: Utilization Networks for Alabama*: Values showing with the edges correspond to the transition probabilities from one provider type to another, the thicker the line, the higher the probability value. The different levels of gray shades of the vertices in the graph correspond to the importance of each node quantified as the expected visit number per patient.*
Legend: PO=physician's office visit; PS=psychological services visit; RX=medication event; MHF=mental health facility outpatient visit; ER=emergency room visit; and OP=other practitioner visit.



AL1: *High Psychological Services/Low Medication (HPS/LRX+(MHF)) Profile (n=586, 10.5%)*

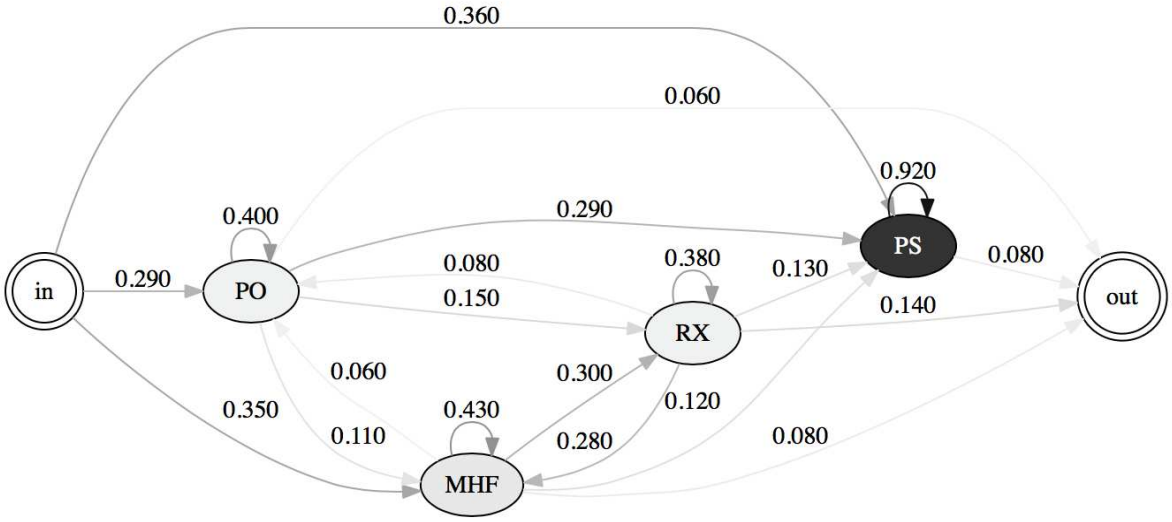


AL2: *Low Psychological Services/Low Medication (LPS/LRX+(ER,MHF,PO)) Profile (n=1,735, 31.1%)*

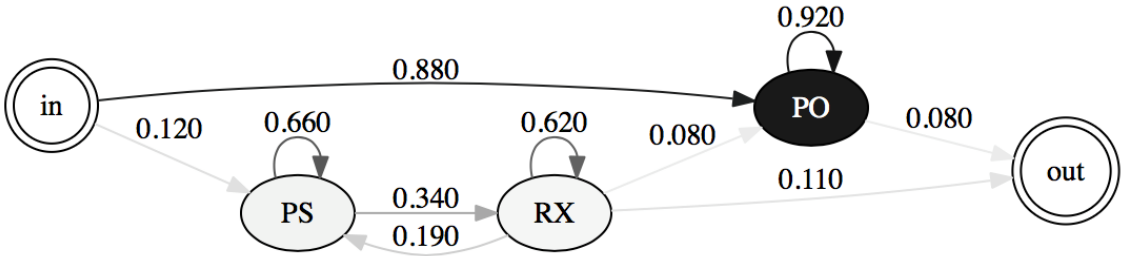


AL3: *Low Psychological Services/High Medication (LPS/HRX+(PO)) Profile (n=3,264, 58.4%)*

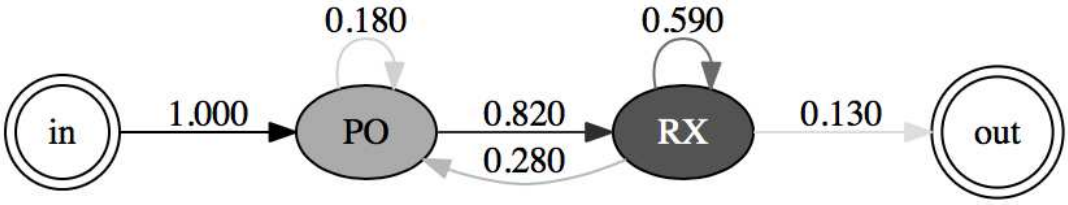
Figure A2: Utilization Networks for Florida*: Values showing with the edges correspond to the transition probabilities from one provider type to another, the thicker the line, the higher the probability value. The different levels of gray shades of the vertices in the graph correspond to the importance of each node quantified as the expected visit number per patient.*
Legend: PO=physician's office visit; PS=psychological services visit; RX=medication event; MHF=mental health facility outpatient visit; ER=emergency room visit; and OP=other practitioner visit.



FL1: *High Psychological Services/Low Medication (HPS/LRX+(MHF,PO)) Profile (n=2,876, 26.3%)*

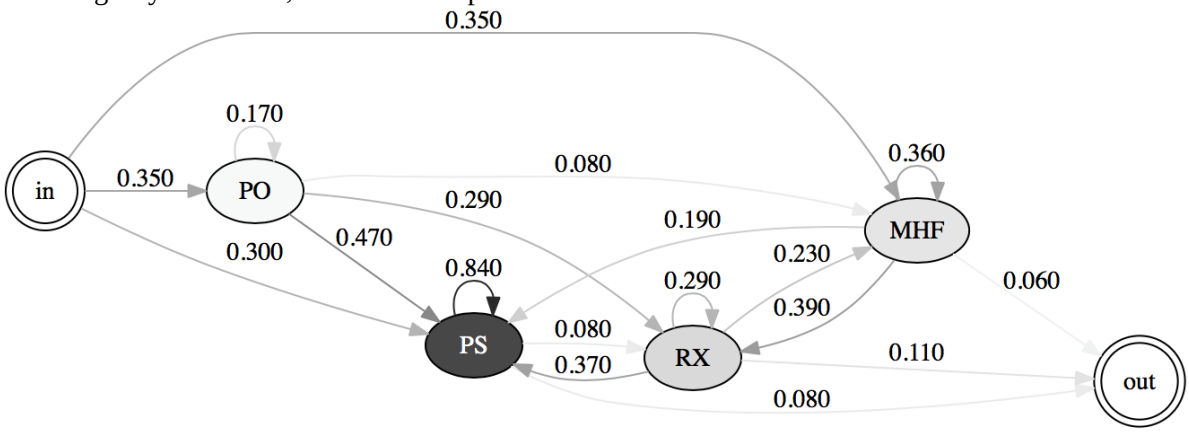


FL2: *Low Psychological Services/Low Medication (LPS/LRX+(PO)) Profile (n=2,727, 25.0%)*

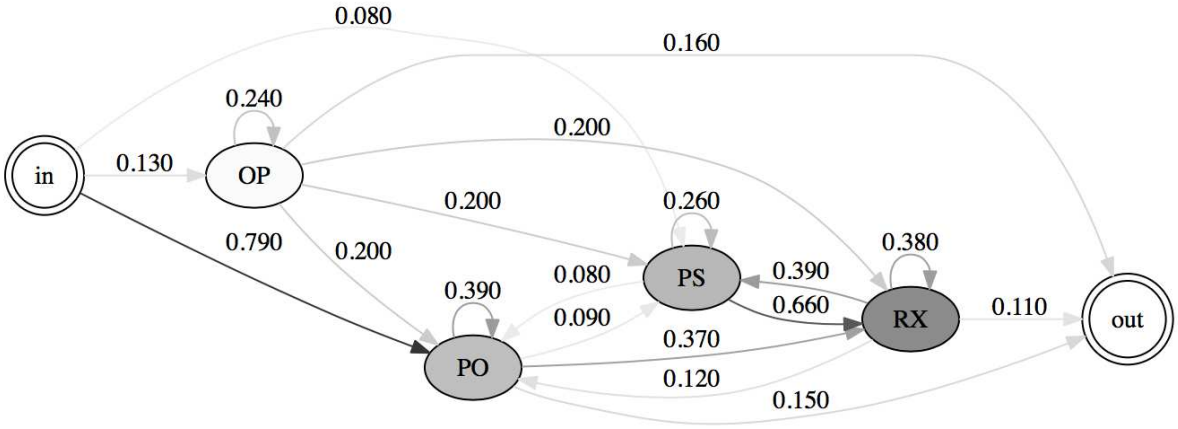


FL4: *High Medication (HRX+(PO)) Profile (n=5,329, 48.8%)*

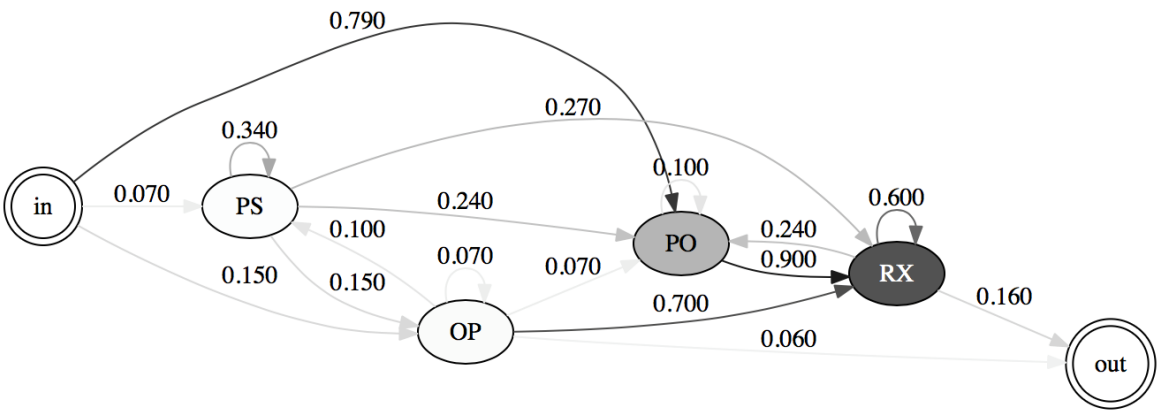
Figure A3: Utilization Networks for Georgia*: Values showing with the edges correspond to the transition probabilities from one provider type to another, the thicker the line, the higher the probability value. The different levels of gray shades of the vertices in the graph correspond to the importance of each node quantified as the expected visit number per patient. Legend: PO*=physician's office visit; PS=psychological services visit; RX=medication event; MHF=mental health facility outpatient visit; ER=emergency room visit; and OP=other practitioner visit.



GA1: *High Psychological Services/Low Medication (HPS/LRX+(MHF,PO)) Profile (n=2,631, 25.9%)*

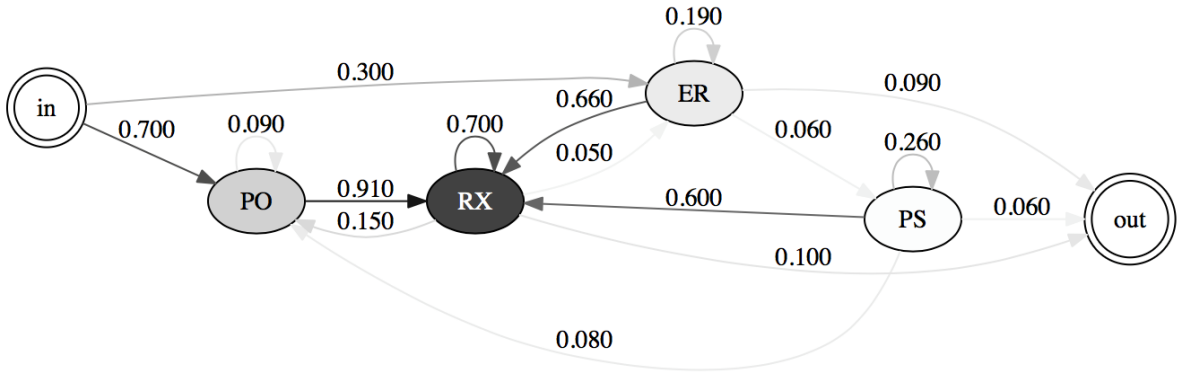


GA2: *Low Psychological Services/High Medication (LPS/LRX)) Profile (n=2,787, 27.4%)*

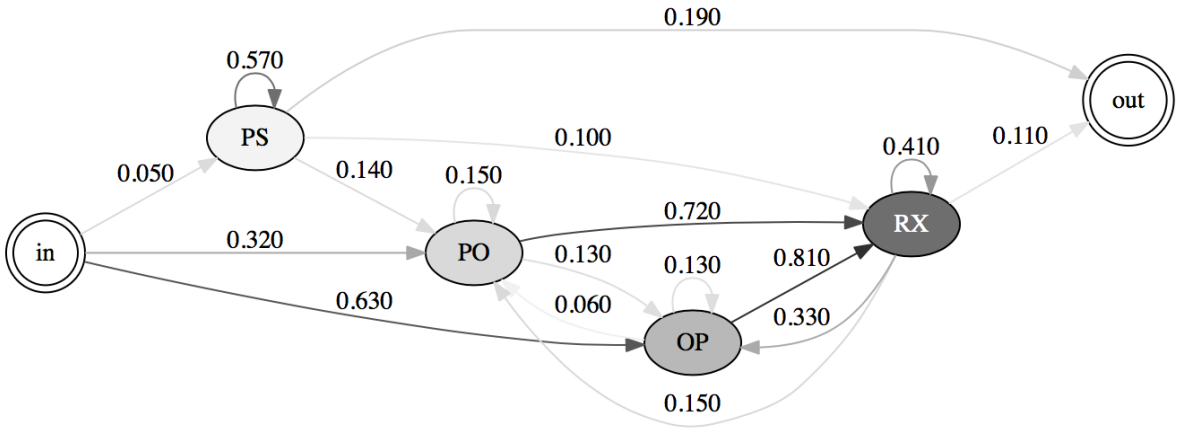


GA3: *Low Psychological Services/High Medication (LPS/HRX+(OP, PO)) Profile (n=4,746, 46.7%)*

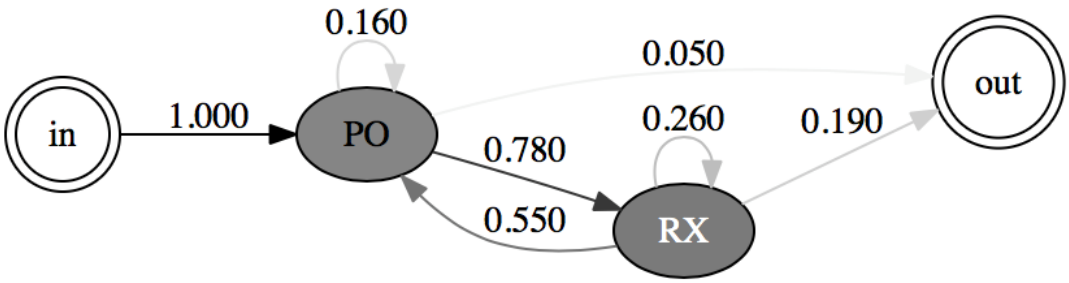
Figure A4: Utilization Networks for Louisiana*: Values showing with the edges correspond to the transition probabilities from one provider type to another, the thicker the line, the higher the probability value. The different levels of gray shades of the vertices in the graph correspond to the importance of each node quantified as the expected visit number per patient. Legend: PO*=physician's office visit; PS=psychological services visit; RX=medication event; MHF=mental health facility outpatient visit; ER=emergency room visit; and OP=other practitioner visit.



LA3a: *Low Psychological Services/High Medication (LPS/HRX+(ER,PO)) Profile (n=2,393, 25.6%)*

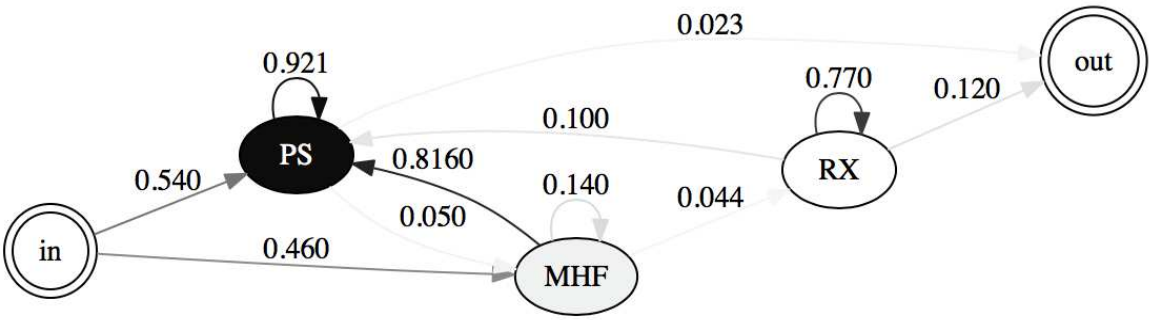


LA3b: *Low Psychological Services/High Medication (LPS/HRX+(OP, PO)) Profile (n=1,479, 15.8%)*

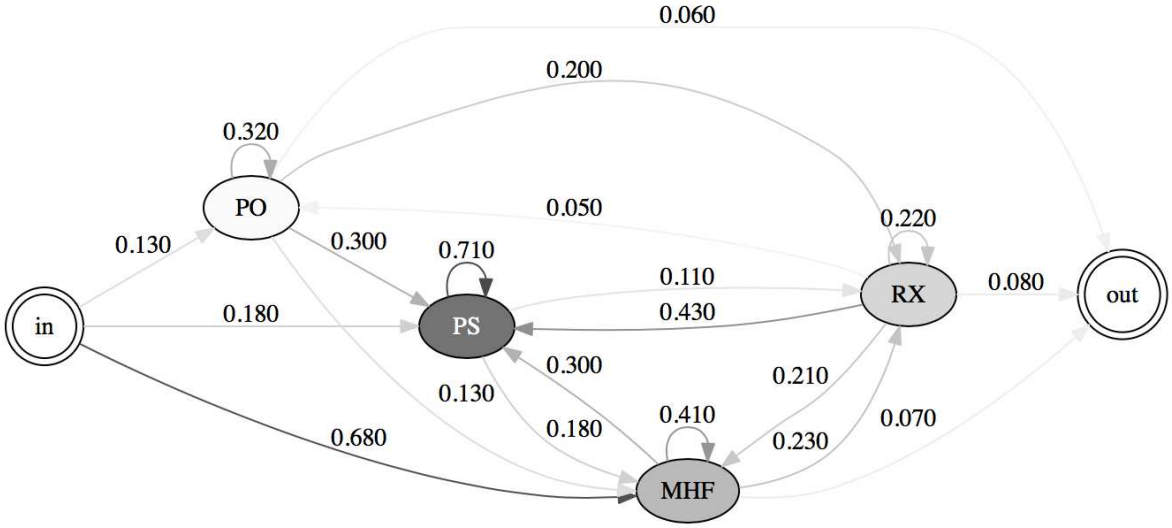


LA4: *High Medication (HRX+(PO)) Profile (n=5,476, 58.6%)*

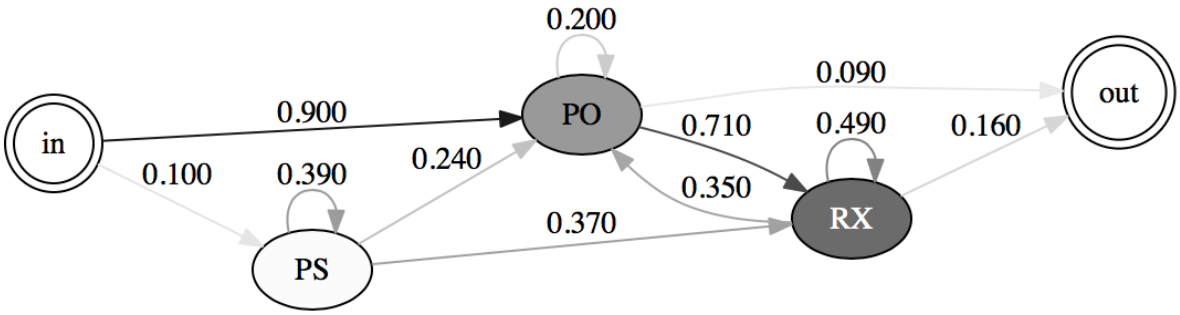
Figure A5: Utilization Networks for Mississippi*: Values showing with the edges correspond to the transition probabilities from one provider type to another, the thicker the line, the higher the probability value. The different levels of gray shades of the vertices in the graph correspond to the importance of each node quantified as the expected visit number per patient. Legend: PO*=physician's office visit; PS=psychological services visit; RX=medication event; MHF=mental health facility outpatient visit; ER=emergency room visit; and OP=other practitioner visit.



MS1: *High Psychological Services/Low Medication (HPS/LRX+(MHF)) Profile (n=1,169, 30.4%)*

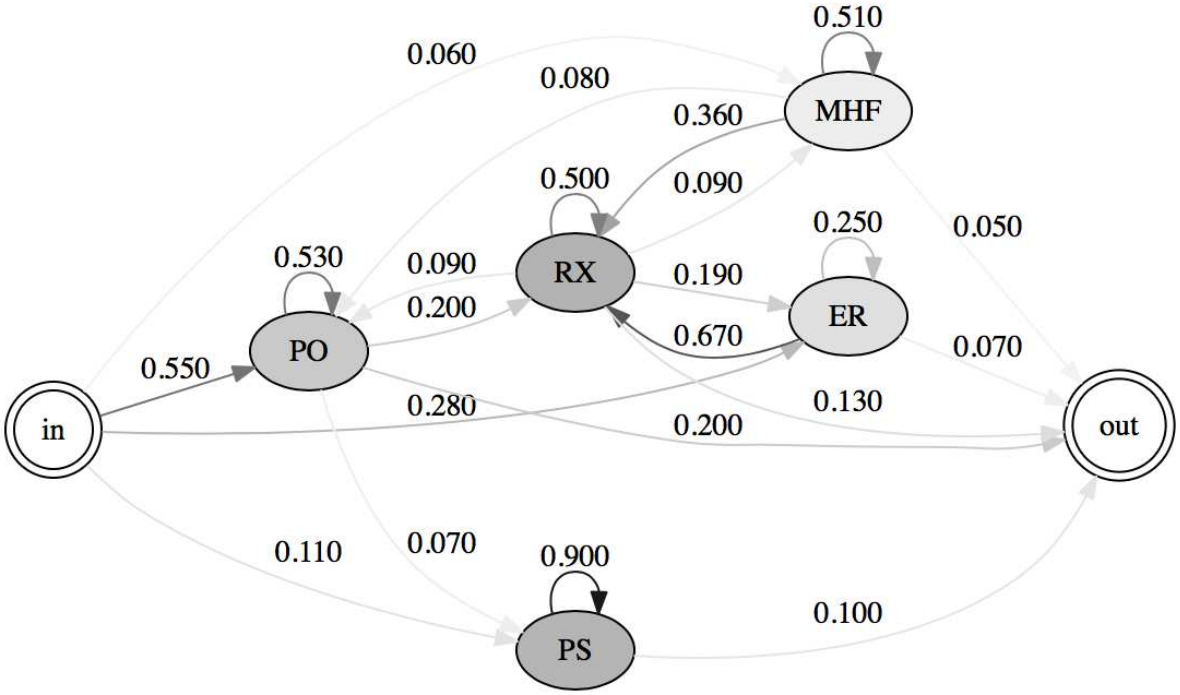


MS2: *Low Psychological Services/Low Medication (LPS/LRX+(MHF,PO)) Profile (n=1,036, 27.0%)*

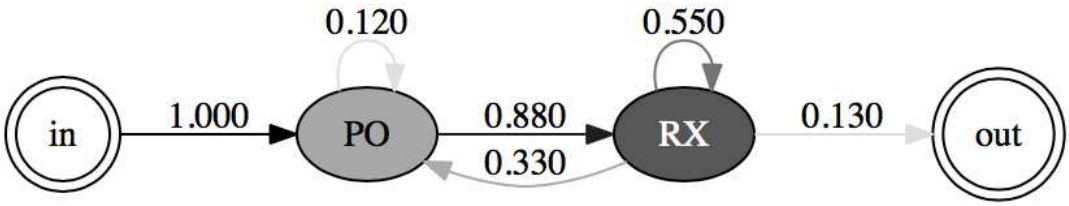


MS3: *Low Psychological Services/High Medication (LPS/HRX+(PO)) Profile (n=1,638, 42.6%)*

Figure A6: Utilization Networks for North Carolina*: Values showing with the edges correspond to the transition probabilities from one provider type to another, the thicker the line, the higher the probability value. The different levels of gray shades of the vertices in the graph correspond to the importance of each node quantified as the expected visit number per patient. Legend: PO*=physician's office visit; PS=psychological services visit; RX=medication event; MHF=mental health facility outpatient visit; ER=emergency room visit; and OP=other practitioner visit.

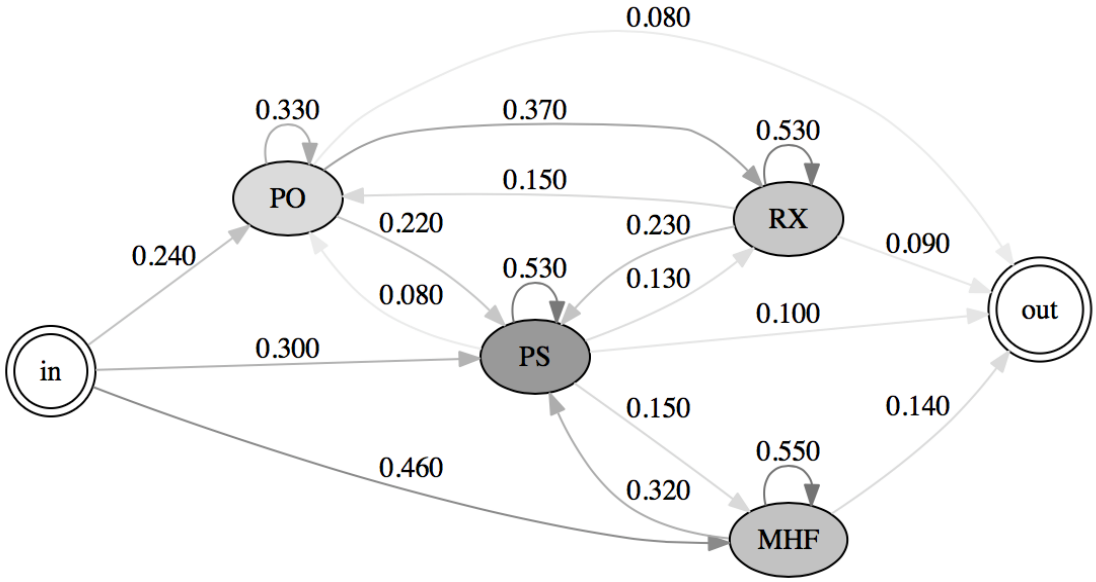


NC2: *Low Psychological Services/Low Medication (LPS/LRX+(ER,MHF,PO) Profile (n=2,015, 20.1%)*

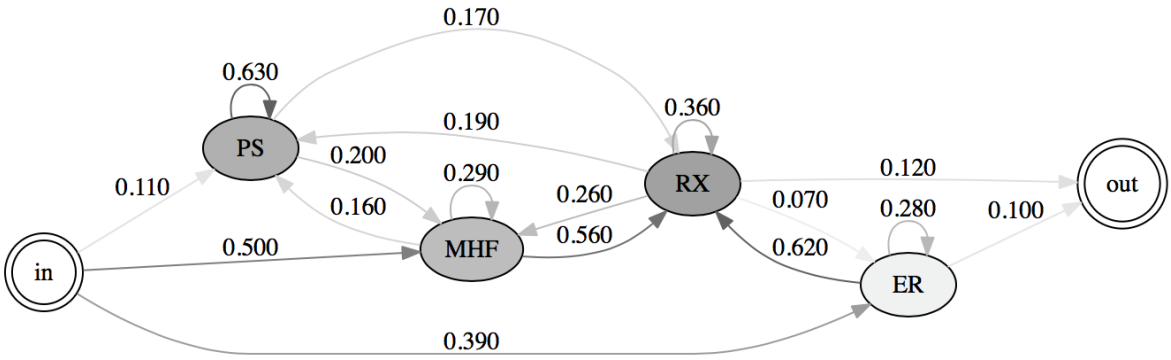


NC4: *High Medication (HRX+(PO)) Profile (n=8,005, 79.9%)*

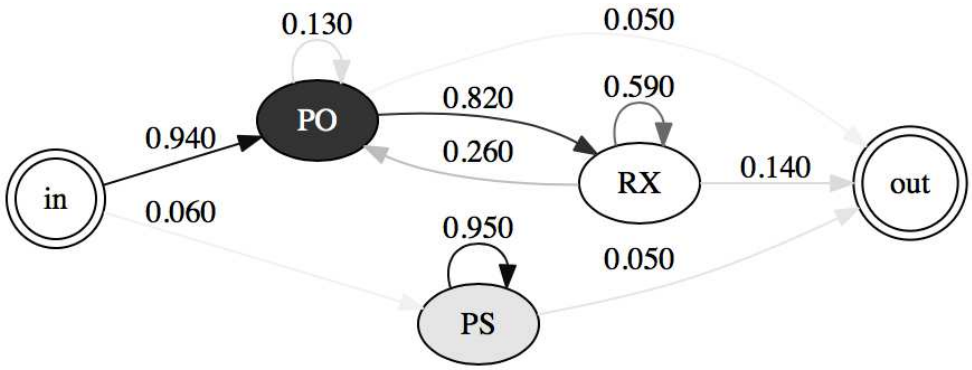
Figure A7: Utilization Networks for South Carolina*: Values showing with the edges correspond to the transition probabilities from one provider type to another, the thicker the line, the higher the probability value. The different levels of gray shades of the vertices in the graph correspond to the importance of each node quantified as the expected visit number per patient. Legend: PO*=physician's office visit; PS=psychological services visit; RX=medication event; MHF=mental health facility outpatient visit; ER=emergency room visit; and OP=other practitioner visit.



SC1: *High Psychological Services/High Medication (HPS/HRX+(MHF,PO)) Profile (n=1,032, 28.9%)*



SC3a: *Low Psychological Services/High Medication (LPS/HRX+(ER,MHF)) Profile (n=814, 22.8%)*



SC3b: Low Psychological Services/*High Medication (LPS/HRX+(PO)) Profile (n=1,722, 48.3%)*