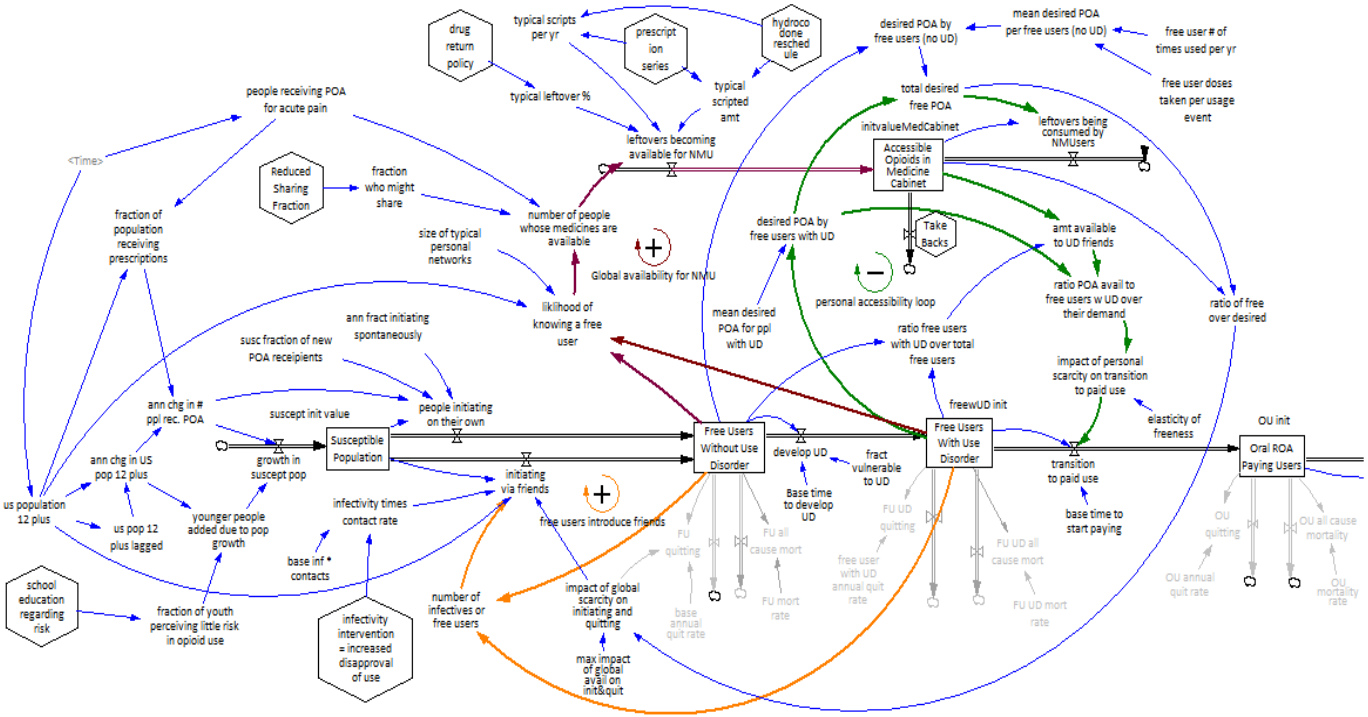
Supplementary material for <W. Wakeland et al.> <Dynamic model of nonmedical opioid use trajectories and potential policy interventions> <The American Journal of Drug and Alcohol Abuse> <2015>

Supplemental Information

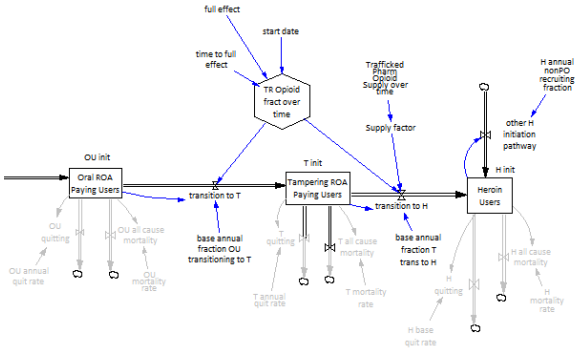
Model Diagram and List of Equations and Parameters

[Note to t/s: Please position Supplementary Figures A and B here with their captions below them. Supplementary Figures A and B are in the Graphics folder within Zipfile]

Supplementary Figure Part A. Lefthand part of the full stock and flow diagram for the computational model.


drug return policy
typical scripts per yr
prescript ion series
hydroco done resched ule
typical leftover %
typical scripted amt
leftovers becoming available for NMU
desired POA by free users (no UD)
mean desired POA per free users (no UD)
free user # of times used per yr
free user doses taken per usage event
total desired free POA
initvalueMedCabinet
Accessible Opioids in Medicine Cabinet
leftovers being consumed by NMUsers
Take Backs
people receiving POA for acute pain
<Time>
Reduced Sharing Fraction
fraction who might share
number of people whose medicines are available
Global availability for NMU
size of typical personal networks
fraction of population receiving prescriptions
likelihood of knowing a free user
desired POA by free users with UD
mean desired POA for ppl with UD
personal accessibility loop
amt available to UD friends
ratio POA avail to free users w UD over their demand
ratio of free over desired
ratio free users with UD over total free users
impact of personal scarcity on transition to paid use
elasticity of freeness
susc fraction of new POA recipients
ann fract initiating spontaneously
people initiating on their own
ann chg in # ppl rec. POA
suscept init value
Susceptible Population
growth in suscept pop
Free Users Without Use Disorder
Free Users With Use Disorder
freewUD init
develop UD
fract vulnerable to UD
transition to paid use
base time to start paying
OU init
Oral ROA Paying Users
ann chg in US pop 12 plus
us population 12 plus
us pop 12 plus lagged
younger people added due to pop growth
initiating via friends
free users introduce friends
infectivity times contact rate
base inf * contacts
number of infectives or free users
impact of global scarcity on initiating and quitting
max impact of global avail on init&quit
base time to develop UD
FU quitting
FU all cause mort
FU mort rate
base annual quit rate
FU UD quitting
free user with UD annual quit rate
FU UD all cause mort
FU UD mort rate
OU quitting
OU all cause mortality
OU annual quit rate
OU mortality rate
school education regarding risk
fraction of youth perceiving little risk in opioid use
infectivity intervention = increased disapproval of use

Supplementary Figure Part B: Righthand part of the full stock and flow diagram for the computational model



Model equations and parameters in alphabetical order

Accessible Opioids in Medicine Cabinet = INTEG (leftovers becoming available for NMU-leftovers being consumed by NMUsers – TakeBacks, initvalueMedCabinet)
all users = Free Users Without Use Disorder+users w UD
amt available to UD friends = Accessible Opioids in Medicine Cabinet*ratio free users with UD over total free users
“ann chg in # ppl rec. POA” = ann chg in US pop 12 plus*fraction of population receiving prescriptions
ann chg in US pop 12 plus = us population 12 plus-us pop 12 plus lagged
ann fract initiating spontaneously = 0.003 [0.0005, 0.002]
base annual fraction OU transitioning to T = 0.3
base annual fraction T trans to H = 0.05 [1–2% prior to 2000, 3–5% 2000 and later from survival analysis of TEDS 1992-2012, KRAL 2013, NSDUH 2000–2012.
base annual quit rate = 0.15
"base inf * contacts" = 6
Base time to develop UD = 5
base time to start paying = 2
"desired POA by free users (no UD)" = Free Users Without Use Disorder*"mean desired POA per free users (no UD)"
desired POA by free users with UD = Free Users With Use Disorder*mean desired POA for ppl with UD
develop UD = Free Users Without Use Disorder*fract vulnerable to UD/Base time to develop UD
drug return policy = 1 - STEP(0.25, 2010.5)
effectofpolydrugtrendondeaths = SMOOTH3I(1+RAMP(0.16, 2000, 2010), 1, 1)
elasticity of freeness = 0.5
fract vulnerable to UD = 0.2
fraction of population receiving prescriptions = people receiving POA for acute pain/us population 12 plus
fraction of youth perceiving little risk in opioid use = 0.47*school education regarding risk [from

MTF 2010, 2011, 2012: 12th graders perceiving risk of trying opioids as moderate, low, or no risk. .45%, 48%, 47%
fraction who might share = 0.35*Reduced Sharing Fraction [36% of 483 college students have diverted their prescripion drugs in their lifetime; 35.1% had diverted opioid anagesics (McCabe et al, 2011)]
free UD OD mortality = 0.001
Free UD ODs = free UD OD mortality*Free Users With Use Disorder*effectofpolydrugtrendondeaths
"free user # of times used per yr" = 20 [NSDUH Analytic Series A-28 (2002–2004), Tables 2.18B, pg. 201 shows # of days used/yr]
free user doses taken per usage event = 1.5 [1 to 5 per Katz 2010; 2 or 3 seems plausible; with 2 being more likely; prev. Expert panel endorsed 2 as well]
free user with UD annual quit rate = 0.2 [less than .25 for UD and paying]
Free Users With Use Disorder = INTEG (develop UD-FU UD all cause mort - FU UD quitting-transition to paid use, freewUD init)
Free Users Without Use Disorder = INTEG (initiating via friends+people initiating on their own-develop UD - FU all cause mort - FU quitting, 4.08e+006)
freewUD init = 300000 [per NSDUH 1995, Passik et al 2006]
FU all cause mort = Free Users Without Use Disorder*FU mort rate
FU mort rate = 0.0084
FU quitting = (Free Users Without Use Disorder*base annual quit rate)*impact of global scarcity on initiating and quitting
FU UD all cause mort = Free Users With Use Disorder*FU UD mort rate
FU UD mort rate = 0.01 [a bit less than those paying]
FU UD quitting = Free Users With Use Disorder*free user with UD annual quit rate
full effect = 0.7*0 [*0 means policy is not active for baseline]
growth in suscept pop = "ann chg in # ppl rec. POA"+younger people added due to pop growth
H all cause mortality = H mortality rate*Heroin Users
H annual nonPO recruiting fraction = 0.02
H base quit rate = 0.05 [low fraction is consistent with long-term nature of H addiction]
H init = 1.351e+006
H mortality rate = 0.012
H ODs = Heroin Users*OD mortality H
H quitting = Heroin Users*H base quit rate
Heroin Users = INTEG (other H initiation pathway + transition to H-H all cause mortality - H quitting, H init)
hydrocodone reschedule = 1 [meaning potential policy not active at baseline]
impact of global scarcity on initiating and quitting = "max impact of global avail on init&quit" + 1/ratio of free over desired
impact of personal scarcity on transition to paid use = elasticity of freeness*(1+1/ratio POA avail to free users w UD over their demand)
"infectivity intervention = increased disapproval of use" = 1 - STEP(0.25 , 2005)*0 [*0 means not for baseline]
infectivity times contact rate = "base inf * contacts"*"infectivity intervention = increased disapproval of use"
initiating via friends = (infectivity times contact rate*Susceptible Population*number of infectives or free users / us population 12 plus)/impact of global scarcity on initiating and quitting

initvalueMedCabinet = 2.5e+009
leftovers becoming available for NMU = number of people whose medicines are available*"typical leftover %"*typical scripted amt * typical scripts per yr
leftovers being consumed by NMUsers = MIN(Accessible Opioids in Medicine Cabinet,total desired free POA)
liklihood of knowing a free user = 1-EXP(-size of typical personal networks*(Free Users With Use Disorder+Free Users Without Use Disorder) / us population 12 plus)
"max impact of global avail on init&quit" = 0.7
mean desired POA for ppl with UD = 200
"mean desired POA per free users (no UD)" = "free user # of times used per yr"*free user doses taken per usage event
number of infectives or free users = Free Users Without Use Disorder+Free Users With Use Disorder
number of people whose medicines are available = people receiving POA for acute pain*liklihood of knowing a free user*fraction who might share
OD mortality H = 0.0015+RAMP(0.00014, 2001, 2009)
Oral ROA Paying Users = INTEG ((transition to paid use-OU all cause mortality-OU quitting-transition to T), OU init)
other H initiation pathway = Heroin Users*H annual nonPO recruiting fraction
OU all cause mortality = Oral ROA Paying Users*OU mortality rate
OU annual quit rate = 0.25
OU init = 180000
OU mortality rate = 0.01
OU OD mortality = 0.001
OU ODs = Oral ROA Paying Users*OU OD mortality*effectofpolydrugtrendondeaths
OU quitting = Oral ROA Paying Users*OU annual quit rate
people initiating on their own = Susceptible Population*ann fract initiating spontaneously+"ann chg in # ppl rec. POA" * susc fraction of new POA recipients
percentage of inits are spont = people initiating on their own/tot initiating [RBP: NSDUH 3.1% in 2006, 3% in 2010 and 4.1% in 2012]
prescription series = 1 {meaning potential policy not active at baseline]
ratio free users with UD over total free users = Free Users With Use Disorder/(Free Users Without Use Disorder+Free Users With Use Disorder)
ratio of free over desired = Accessible Opioids in Medicine Cabinet/total desired free POA
ratio POA avail to free users w UD over their demand = amt available to UD friends/desired POA by free users with UD
rec user OD mortality = 0.0002
rec user ODs = Free Users Without Use Disorder*rec user OD mortality*effectofpolydrugtrendondeaths
sharing reduction policy = 1 - (STEP (0.25, 2005)*1)*0 [*0 means policy not active for baseline]
size of typical personal networks = 30
start date = 2010.5 [for policy intervention]
Supply factor = SMOOTH3 (1/Trafficked Pharm Opioid Supply over time, 1, 0.3)
susc fraction of new POA recipients = 0.075
suscept init value = 7.5e+006
Susceptible Population = INTEG (growth in suscept pop-initiating via friends-people initiating on their own, suscept init value)

T all cause mortality = T mortality rate*Tampering ROA Paying Users
T annual quit rate = 0.1
T init = 240000
T mortality rate = 0.012
T OD mortality = 0.0015
T ODs = T OD mortality*Tampering ROA Paying Users*effectofpolydrugtrendondeaths
T quitting = Tampering ROA Paying Users*T annual quit rate
TakeBacks = 0 + (STEP (5e+007,2010.5))*0 [*0 means policy not active at baseline]
Tampering ROA Paying Users= INTEG ((transition to T-T all cause mortality-T quitting-transition to H),T init)
time to full effect = 6
tot initiating = initiating via friends + people initiating on their own
total desired free POA = "desired POA by free users (no UD)"+desired POA by free users with UD
total opioid ODs = Free UD ODs+OU ODs+rec user ODs+T ODs
TR Opioid fract over time = 0+RAMP(full effect/time to full effect , start date , start date+time to full effect))*0 [*0 means TR policy is not active for baseline]
Trafficked Pharm Opioid Supply over time = 3.5 - RAMP(0.27,1995,2006) - RAMP (0.05, 2006,2010) [external input from a separate study by the authors]
transition to H = Tampering ROA Paying Users*base annual fraction T trans to H*Supply factor * (1/(1-TR Opioid fract over time))
transition to paid use = (Free Users With Use Disorder/base time to start paying)*impact of personal scarcity on transition to paid use
transition to T = Oral ROA Paying Users*base annual fraction OU transitioning to T*(1-TR Opioid fract over time)
"typical leftover %" = 0.34*drug return policy [imputed from Tufts Healthcare Inst. Program on Opioid Risk Mgmt 2010
typical scripted amt = 45*hydrocodone reschedule*prescription series [two potential policies not used in present study]
typical scripts per yr = 1.5*hydrocodone reschedule*prescription series [see above]
UD oral users = Free Users With Use Disorder + Oral ROA Paying Users
us pop 12 plus lagged = DELAY1I(us population 12 plus,1,2.09e+008)
us population 12 plus = 2.11532e+008*EXP(0.015*(Time-1995)) [reported in NSDUH]
users w UD = UD oral users + Tampering ROA Paying Users
younger people added due to pop growth = ann chg in US pop 12 plus*fraction of youth perceiving little risk in opioid use.