Network modeling the impact of community-based male-screeing on the Chlamydia prevalence in women

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Outlines

1. Introduction of Chlamydia disease
2. Mathematical modeling of Chlamydia
3. Study the impact of male-screening intervention
Chlamydia - most commonly reported sexually transmitted disease (STD)

- Chlamydia is an infection with *Chlamydia trachomatis* bacteria.
- Ct is the most commonly reported STD in the U.S.
  - 1.7 million cases, CDC 2017 Surveillance
  - 2.9 million cases, estimated, under-reporting
  - 22% increase since 2013

Cases per 100,000 population (2017) both sexes, all races/ethnicities

Chlamydia - LA, 742
  - black/AA, 1595
    - age 15-24, 7153
      - female, 10323
                    (~1/10)
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“Silent” infection leads to serious consequences in women

- symptomatic infection in only 10% of men and 30% women

Untreated Chlamydia can cause serious, permanent damage to a woman's reproductive system:
- infertility
- pelvic inflammatory disease
- ectopic pregnancy
- pre-term delivery
- eye inflammation/pneumonia in the newborn

Increased HIV risk

Chlamydia treatment:

Chlamydia can be easily cured with antibiotics.

Repeat infection with chlamydia is common.

Screening is necessary to identify most infections.
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Untreated Chlamydia

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Chlamydia treatment

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Screening is necessary to identify most infections.
Introduction of Chlamydia disease

CDC: routine screening policy for women, but not for men

Annual screening is recommended for high-risk women

- sexually active women <25 years old
- older women with risk factors (new or multiple partners)
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Question: will screening men reduce rates in women?
- Men could be an important reservoir of infection for women
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“Check It”, a male-screening based program, targets
  - African American men
  - age 15-24, live in New Orleans
  - sexually active (at least one sexual contact in the past two months)
Goal: model and quantify the impacts of male-screening strategy
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We create a mathematical model for Chlamydia epidemic:

- stochastic, heterosexual, individual-based
- simulates Chlamydia transmission over sexual networks
- describes the interventions for the epidemic
Outlines

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2. Mathematical modeling of Chlamydia

3. Study the impact of male-screening intervention
Network modeling to describe heterosexual partnership
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- heterosexual network, node = person, edge = sexual partnership
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- dynamic sexual networks, partner changes in time
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- heterosexual network, node = person, edge = sexual partnership
- dynamic sexual networks, partner changes in time
- primary (long-term) vs. casual (short-term)
Realistic sexual networks need biased mixing
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1. social mixing: social network gives biased mixing from age, spatial location, social status, etc
Realistic sexual networks need biased mixing

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- TRANSIMS infrastructure, tracks social activities, 150K population, New Orleans (Bryan Lewis, Achla Marathe, U Virginia)
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Realistic sexual networks need biased mixing

1. social mixing: social network gives biased mixing from age, spatial location, social status, etc
2. sexual mixing: how many partners? primary or casual?
Realistic sexual networks need biased mixing

1. social mixing: social network gives biased mixing from age, spatial location, social status, etc

2. sexual mixing: how many partners? primary or casual?
   - data from “Check It” and “You Geaux Girl!”
Realistic sexual networks need biased mixing

1. social mixing: social network gives biased mixing from age, spatial location, social status, etc
2. sexual mixing: how many partners? primary or casual?

Check It, men’s perspective

- enrolled 1318 AA men
  (ongoing, as of April 2019)
- survey questionnaire on
  - sexual behavior
  - partner demographics

https://gocheckit.net/
Realistic sexual networks need biased mixing

1. social mixing: social network gives biased mixing from age, spatial location, social status, etc

2. sexual mixing: how many partners? primary or casual?

You Geaux Girl!, women’s perspective (Jakevia L. Green, 2014, Tulane)
- enrolled 649 AA women
- survey questionnaire on
  - sexual behavior
  - partner information

Pregnancy prevention intervention for young AA women
Realistic sexual networks need biased mixing

1. social mixing: social network gives biased mixing from age, spatial location, social status, etc

2. sexual mixing: how many partners? primary or casual?

- social network
- sexual behavior survey

dynamic sexual networks
Realistic sexual networks need biased mixing

1. Social mixing: social network gives biased mixing from age, spatial location, social status, etc.
2. Sexual mixing: how many partners? Primary or casual?

\[ \sim 80\% \text{ of partnerships from one’s heterosexual social network} \]
Realistic sexual networks need biased mixing (population = 5000)
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Chlamydia transmission on sexual network - SIS model

Susceptible (S) \rightarrow \text{force of infection} \rightarrow \text{Infected (I)}

\text{treated or natural recovery}

- force of infection combining risk factors
  - number of partners
  - probability of having a sexual contact
  - probability of using a condom
  - type of partnership (primary or casual)

\text{I} \rightarrow \text{S}: \text{Chlamydia infection does not confer lasting immunity after treatment or natural clearance; individual may have repeat infections once susceptible}
Chlamydia transmission on sexual network - SIS model

- **S → I**: force of infection combining risk factors
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- individual may have repeat infections once susceptible
Mathematical modeling of Chlamydia Disease dynamics on network

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Investigate the effectiveness of male-screening strategy

We need to have a comprehensive description for

- the existing intervention approaches
- Check It male-screening intervention program

to study the *net* impact of male-screening strategy given the existing policy
Investigate the effectiveness of male-screening strategy

We need to have a comprehensive description for

- the existing intervention approaches → baseline scenario
- Check It male-screening intervention program

to study the net impact of male-screening strategy given the existing policy
Baseline intervention strategies

- **women annual screening**
  as regular preventive healthcare
Baseline intervention strategies

- **women annual screening** as regular preventive healthcare
- **index treatment** by antibiotic
Baseline intervention strategies

- **women annual screening** as regular preventive healthcare
- **index treatment** by antibiotic
- **expedited partner treatment** (EPT) partner treated w/o diagnostic

[Diagram of intervention strategies]

- Annual Exam (women only)
  - Screening
  - Index Treatment
  - Partner Treatment
Baseline intervention strategies

- **women annual screening** as regular preventive healthcare
- **index treatment** by antibiotic
- **expedited partner treatment** (EPT) partner treated w/o diagnostic
- **rescreening** three months after initial infection
Baseline intervention strategies

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  - **index treatment** by antibiotic
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- **women clinic visit** for symptomatic infection
  - about 30% cases in women
  - same procedure if infected
Baseline intervention strategies

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  - **index treatment** by antibiotic
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- **women clinic visit** for symptomatic infection
  - about 30% cases in women
  - same procedure if infected

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Baseline intervention strategies

- **women annual screening**
- **women clinic visit**
- **men clinic visit** for symptomatic infection
  - about $\sim 10\%$ cases in men
  - index treatment
Baseline intervention strategies

- **women annual screening**
- **women clinic visit**
- **men clinic visit**

Check It male-screening
Baseline intervention strategies

- **women annual screening**
- **women clinic visit**
- **men clinic visit**

Check It male-screening

- **venue-based enrollment**
  - high-prevalence neighborhoods
  - barbershops, community colleges, universities
Baseline intervention strategies

- **women annual screening**
- **women clinic visit**
- **men clinic visit**

Check It male-screening

- **venue-based enrollment**
- **expedited index treatment**
Baseline intervention strategies

- **women annual screening**
- **women clinic visit**
- **men clinic visit**

Check It male-screening

- **venue-based enrollment**
- **expedited index treatment**
- **expedited partner treatment**
  - partnering community pharmacies w/o diagnostic
- **rescreening**
Baseline intervention strategies

- women annual screening
- women clinic visit
- men clinic visit

Check It male-screening

- venue-based enrollment
- expedited index treatment
- expedited partner treatment
- rescreening
- social network peer referral
  - refer friends in social network
  - referral coupon, monetary incentive
  - word-of-month, peer effect, etc
Mathematical modeling of Chlamydia

Modeling the intervention strategies

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Outlines

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Check It intervention at current intensity

Current intervention intensity of Check It

- venue-based enrollment 7.5% per year
  - peer-recruited: about every three men bring one more friend
- index treatment rate 76%, delay = 12 days
- partner treatment rate 27%, delay = 2 days
- rescreening 8%, delay = 102 days
Study the impact of male-screening intervention

Check It intervention at current intensity

![Graph showing the prevalence of Chlamydia infection over the years for women (in pink) and men (in green).](image)

- **y-axis**: Prevalence of Ct infection (in percentage)
- **x-axis**: Year (from -3 to 12 years)

- **Legend**:
  - Pink line: women
  - Green line: men
Study the impact of male-screening intervention

Check It intervention at current intensity

![Graph showing the prevalence of Chlamydia infection over time, with lines for women and men, indicating a decrease after the implementation of Check It intervention.]
Check It intervention at current intensity

achieve a quasi-steady state around year 5

Baseline (before Check It) → after Check It
Study the impact of male-screening intervention

Check It intervention at current intensity

![Graph showing the prevalence of Chlamydia infection over time, with a quasi-steady state around year 5.](image)

- **Women**: 13.5%, 12.4%
- **Men**: 10.2%, 9.3%

Baseline (before Check It) vs. after Check It
Check It intervention at current intensity

Achieve a quasi-steady state around year 5

8.1% ↓ in women
8.8% ↓ in men

Baseline (before Check It) — after Check It
Male-screening intervention help to reduce Chlamydia prevalence in women
Study the impact of male-screening intervention

Male-screening intervention help to reduce Chlamydia prevalence in women
Male-screening intervention help to reduce Chlamydia prevalence in women

(current Check It intervention level vs. Baseline)

Study the impact of male-screening intervention
Male-screening intervention help to reduce Chlamydia prevalence in women

30% reduction in prevalence for women

Current Check It intervention level

Baseline
Male-screening intervention help to reduce Chlamydia prevalence in women

- 30% reduction in prevalence for women
- Current Check It intervention level
- Baseline
- VBS = 30%
- EPT = 40%

Study the impact of male-screening intervention.
Male-screening intervention help to reduce Chlamydia prevalence in women

30% reduction in prevalence for women

VBS = 23%
EPT = 70%

current Check It intervention level

Baseline
Conclusion

- We proposed a stochastic, heterosexual and individual-based model that describes
  - the Chlamydia epidemic over sexual networks, and
  - the ongoing intervention strategies to control the prevalences.
- Our model
  - provides a mathematical framework to quantify how effective different combinations of interventions will be in mitigating Chlamydia, and
  - predicts that venue-based screening of young African American men has the potential to affect women's rates
Acknowledgment

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