Supplemental Methods

Prevalence of each B. burgdorferi strain in patients

OspC types A,B,E,G,H,I,K,N
Dataset #1 20,20,30,20,70,10,20,10
Dataset #2 28,28,13,5,14,73,13,9
Dataset #3 1,1,1,1,1,1,1,1

Code for stochastic simulation model implemented as a Macro in Microsoft Excel.

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Option Explicit

Sub model()

Dim patient As Single
Dim time As Single
Dim immunity_time As Single
Dim s1 As Single
Dim s2 As Single
Dim s3 As Single
Dim s5 As Single
Dim infection As Single
Dim challenge_infection As Single
Dim replicate As Single
Dim n As Single
Dim index As Single
Dim bite As Single
Dim immu As Single
Dim prob_im As Single

Dim strn As String
Dim challenge_strain As String
Dim s4 As String

Dim strain(), year(), count_second_infection(), second_infection(),
repeate_strain(), biteprob() As Variant

Dim temp_array As Variant               'temporal array, it could be read
and written many times during execution
Dim itm As Variant

Dim yearmax() As Single
ReDim yearmax(17) As Single
Dim add_episodes() As Single

Dim total_runs As Single

Dim immunity As Boolean
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Dim repeate_strain_bn As Boolean

'Initiate the model and read initial parameters

Sheets("input").Select
Range("A1").Activate

Randomize

s1 = 2                  '1 = follow Nadelman et al. 2012; 2 = follows
Wormser et al. 2008; 5 = even distribution
s2 = 1                  '1 = complete data set 2 = restricted data set
n = 10000         'number of replicates
s4 = yes          '34 > number of total infections > 39

ReDim strain(n, 17, 50), year(n, 17, 50) As Variant
ReDim add_episodes(n) As Single
ReDim count_second_infection(n) As Variant
ReDim second_infection(n, 17) As Variant
ReDim repeate_strain(n) As Variant
ReDim biteprob(n) As Variant



    If s2 = 1 Then temp_array =
Split("16,14,13,12,6,11,10,9,12,14,9,7,14,12,18,3,9", ",")
    If s2 = 2 Then temp_array =
Split("7,14,3,5,2,5,3,3,6,8,3,4,4,2,15,5,7", ",")

    index = 1
    For Each itm In temp_array
        yearmax(index) = itm
        index = index + 1
    Next itm

For immu = 0 To 18

immunity_time = immu


total_runs = 0

'initiate replicates
For replicate = 1 To n

biteprob(replicate) = Rnd

count_second_infection(replicate) = 0
add_episodes(replicate) = 0
repeate_strain(replicate) = 0

'run model by patient

For patient = 1 To 17
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infection = 1

'determine the strain of the initial infection

    Call pick_strain(s1, strn)

    strain(replicate, patient, 1) = strn
    year(replicate, patient, 1) = 0
    repeate_strain_bn = False

'then, assess if new infection happens

    For time = 1 To yearmax(patient)

        If biteprob(replicate) > Rnd Then

            Call pick_strain(s1, strn)
            challenge_strain = strn
            immunity = False

            'check if strain infection already produced immunity

                For index = 1 To infection

                    If strain(replicate, patient, index) =
challenge_strain And (time - year(replicate, patient, index)) <
immunity_time Then
                        immunity = True
                    Else: End If

                Next index

                    If immunity = False Then

                        For index = 1 To infection

                            If strain(replicate, patient, index) =
challenge_strain Then repeate_strain_bn = True

                        Next index

                        If repeate_strain_bn = True Then
repeate_strain(replicate) = repeate_strain(replicate) + 1

                        second_infection(replicate, patient) = 1

                        infection = infection + 1
                        strain(replicate, patient, infection) =
challenge_strain
                        year(replicate, patient, infection) = time
                        add_episodes(replicate) = add_episodes(replicate)
+ 1
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                    End If

        End If

    Next time
    count_second_infection(replicate) = second_infection(replicate,
patient) + count_second_infection(replicate)

Next patient

If s4 = "yes" Then If add_episodes(replicate) + 17 < 34 Then replicate =
replicate - 1
If s4 = "yes" Then If add_episodes(replicate) + 17 > 39 Then replicate =
replicate - 1

total_runs = total_runs + 1

DoEvents

Next replicate

Range("E1").Activate

    ActiveCell.Offset(0, 4 + immu) = immu

For replicate = 1 To n

    ActiveCell.Offset(replicate + 2, 4 + immu) =
repeate_strain(replicate)

    ActiveCell.Offset(replicate + 4 + 10000, 4 + immu) =
add_episodes(replicate) + 17

    ActiveCell.Offset(replicate + 6 + 20000, 4 + immu) =
biteprob(replicate)

Next replicate

Next immu

DoEvents

End Sub

Sub pick_strain(s1 As Single, strn As String)

Dim llimit1, llimit2, llimit3, llimit4, llimit5, llimit6, llimit7,
llimit8 As Single
Dim ulimit1, ulimit2, ulimit3, ulimit4, ulimit5, ulimit6, ulimit7,
ulimit8 As Single
Dim type_count() As Single
ReDim type_count(8) As Single
Dim count As Single
Dim itm As Variant
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Dim type_prob() As Single
ReDim type_prob(8) As Single
Dim index, draw As Single
Dim temp_array As Variant
'Dim strn As String

'pick the type probability according to user's selection

If s1 = 1 Then temp_array = Split("20,20,30,20,70,10,20,10", ",")
'Nadelman et al. 2012
If s1 = 2 Then temp_array = Split("28,28,13,5,14,73,13,9", ",")
'Wormser et al. 2008
If s1 = 3 Then temp_array = Split("3,2,3,3,1,9,1,2", ",")
'Nadelman EM
If s1 = 4 Then temp_array = Split("1,1,1,1,2,0,0,0", ",")
'Nadelman Blood
If s1 = 5 Then temp_array = Split("1,1,1,1,1,1,1,1", ",")
'even
If s1 = 6 Then temp_array = Split("1,0,0,0,0,0,0,0", ",")
'single strain
If s1 = 7 Then temp_array = Split("1,1,0,0,0,0,0,0", ",")

index = 1

For Each itm In temp_array
    type_count(index) = itm
    index = index + 1
    count = count + itm
Next itm

For index = 1 To 8
    type_prob(index) = type_count(index) / count
Next index


llimit1 = 0
ulimit1 = type_prob(1)
llimit2 = ulimit1
ulimit2 = type_prob(2) + llimit2
llimit3 = ulimit2
ulimit3 = type_prob(3) + llimit3
llimit4 = ulimit3
ulimit4 = type_prob(4) + llimit4
llimit5 = ulimit4
ulimit5 = type_prob(5) + llimit5
llimit6 = ulimit5
ulimit6 = type_prob(6) + llimit6
llimit7 = ulimit6
ulimit7 = type_prob(7) + llimit7
llimit8 = ulimit7
ulimit8 = type_prob(8) + llimit8

Randomize
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draw = Rnd

If 0 < draw And draw < ulimit1 Then strn = "A"
If llimit2 < draw And draw < ulimit2 Then strn = "B"
If llimit3 < draw And draw < ulimit3 Then strn = "E"
If llimit4 < draw And draw < ulimit4 Then strn = "G"
If llimit5 < draw And draw < ulimit5 Then strn = "H"
If llimit6 < draw And draw < ulimit6 Then strn = "I"
If llimit7 < draw And draw < ulimit7 Then strn = "K"
If llimit8 < draw And draw < ulimit8 Then strn = "N"

End Sub

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