Social and Childcare Provision in Kinship Networks

1. **Purpose and patterns.**
   The purpose of this model is the simulation of social and childcare provision in the UK, in which households can decide to provide for informal care, or pay for private care, for their loved ones, after they have provided for childcare needs. Agents base these decisions on factors including their own health, employment status, financial resources, relationship to the individual in need and geographical location.
   The patterns used as criteria for evaluating the model's suitability for its purpose are based on the available empirical data regarding the care need and care availability patterns. The results demonstrate that the model can produce care provision patterns that are largely compatible with the real-world trends.
2. **Entities, state variables, and scales.**
   The model has three main entities: agents, houses and households. The agents' variables can be classified in five main groups:
   a. *Demographic variables*: gender, age, life expectancy.
   b. *Relational variables*: partner, mother, father and children.
   c. *Socio-economic variables*: Socioeconomic status, activity status, income, working hours, cumulated work experience, wealth.
   d. *Childcare and social care variables*: social care need level, social care need (hours per week), unmet care need, social care supply, social care and childcare work (hours of care provided per week).
   e. *Location-related variables*: town, house, years in the same town.

   Houses are characterized by the following variables: coordinates, town and list of occupants. Agents living in the same house represent a *household*. Instead of creating a new kind of agent, we associated the household's house with household-level variables: total childcare need, childcare cost, total informal care supply, net care need, income for childcare and income for social care.
   The space is represented by a 2-level grid. At the higher level, an 8x12 grid represents roughly the UK map. Each cell in this high-level grid is composed by a 35x35 grid, which represents the space at the lower level. Houses occupy random cells of these lower-level grids, with their number reflecting, in relative terms, the real-world population densities: the grids corresponding to the UK areas with the highest population density will contain 1225 houses (i.e., 35 times 35), whereas, at the other end, desert UK areas correspond to empty grids in the map.
   The model updates in 1-year time steps, each step representing a typical week for that year.

3. **Process overview and scheduling.**
   Each 1-year time step of the simulation unfolds through the following sequence of 14 steps:
   a. *Deaths*: agents are removed from the population with a given probability depending on the year and the agents' age, SES and care need level. Here, the agent's life expectancy if computes, as the maximum between the number of years to reach the age of 90 years, and a fixed number of years which is a parameter of the model.

b. *Adoptions*: If the children's parents split and the mother died, they move with the father. If both parents have died, they are adopted by other couples. Students whose parents have died start working.
c. *Social care transitions*: agents pass to higher care need levels with a probability depending on age, gender, SES and unmet care need.
d. *Social care need update*: the agents' social care need for the period is updated. The social care need net of the social care funded by the government is computed. The share of personal wealth and the amount of wealth allocated to social care are computed, as a function of the total financial wealth and life expectancy.
e. *Childcare need update*: the children's childcare needs are updated (net of the free childcare provided by the government), the total household's childcare need, and its associated cost are computed. The childcare need is divided into a high-cost childcare (whose cost is higher than the social care) and low-cost childcare (whose cost is lower than social care).
f. *Social care supply*: the agents' informal care supply and the household's total income (to pay for formal childcare) for the period are updated.
g. *Update households' and agents' care network*: the two relevant care supplying networks, i.e., the households' childcare network and the agents' social care network are updated. Moreover, the households' care demand network is updated.
h. *Update households' net care demand*: for each household, the net care demand, i.e., the difference between the household's total care need (the sum of social and childcare need) and the household's total informal care is computed.
i. *Childcare provision*: a loop for the childcare provision starts, running until there are households with childcare needs with available care supply. In each cycle of the loop, a household with childcare need is selected with a probability proportional to the remaining childcare need of the household. If the cost of formal childcare is above the formal social care cost, the childcare need will be preferably satisfied through informal care, if available. Otherwise, the household's income will be used to buy formal childcare. If the household has low-price childcare, both informal and formal care can be provided according to the amount of informal care compared to the amount of the household's social care need.
j. *Social care provision*: a loop for the social care provision starts, running until there are agents with social care needs with available care supply. In each cycle of the loop, a care receiver is randomly sampled with probabilities proportional to the amount of unmet social care need. Then, a source of care is randomly sampled from all the care receiver's possible sources (i.e., the households in an agent's kinship network and the agent's own wealth), with probabilities proportional to their amount. A 'quantum' of care is transferred form the care supplier to the care receiver. If a care supplier living in a different town of that of the care receiver or the care receiver's own wealth are selected as the source of care, only formal care is possible, otherwise both informal and formal care are possible with probabilities which depend on relative amount.

k. *Age Transitions*: the age of the agents is incremented, and their age-related status is updated (i.e., from children to teenager, from teenager to student, from student to worker, from worker to retired).
l. *Births*: married women give birth to new agents with a probability depending on the year and the women's age and SES.
m. *Income update*: the workers' hourly wage is updated to reflect the agents' work experience. Then, their income is updated to reflect the agents' working hours. The agents reaching the pension age will retire and start getting a pension. The tax on incomes and the agents' after-tax income are computed.
n. *Update wealth:* a wealth is assigned to agents to reproduce the wealth distribution of the UK, based on the agents' cumulated income, net of the expenses for childcare and social care.
o. *Social Transitions*: from then age of 16 (and then every 2 years up to the age of 24) students decide whether to start working or keep studying, depending on their family income per capita, their parents' SES and their care responsibilities. If they start looking for a job, they are assigned the SES associated with the education level they have reached.
p. *Divorces*: some couples dissolve their partnership, with a probability which depends on age and SES. When a divorce happens, the male agent relocates to another house, leaving the ex-wife and children in the current house.
q. *Marriages*: some singles get married and go to live together with a probability depending on age, SES, geographical location, their activity status and the number of children.
r. *Relocations*: in each period, several agents with relocate to other towns. We divided the relocation process into five processes:
    i. Relocation of agents who married in the current period.
    ii. Relocation of adult agents living with their parents.
    iii. Relocation of adult singles.
    iv. Relocation of retired agents.
    v. Relocation of households.

    Agents who got married in the current period are reunited, as they (and their children) move into a new house in the current town of one of the partners, or in a town nearby. With a certain probability which is given by the product of a base rate and an age-specific rate, adult agents living with their parents relocate to another house, in the current town of in a nearby town. With a certain probability which is given by the product of a base rate and an age-specific rate, independent singles relocate to another house, in the current town of in a nearby town. With a certain probability which is given by the ratio between a base rate and the distance between their children's houses, lone pensioners relocate into the household of one of their children (if any). Finally, in each period every household will relocate to another town with a certain probability which depends on a number of factors related to the cost of relocation, the household's income, the 'social care' and 'socioeconomic' attraction of towns, the availability and affordability of houses.

4. Design concepts

a. *Basic principles.* The model addresses the problem of informal social care availability in modern societies and how it is affected by demographic changes, across socioeconomic classes. Although this problem is often debated in the public arena, no other examples of models addressing this problem were available to the best of the authors' knowledge. While the demographic processes are driven by empirical fertility and mortality rates, no formal behavioural theory of the provision of social care has been developed yet. Therefore, in our model, social care provision is a stochastic process whose plausibility is based on the general 'common sense' principles according to which:

   i. The amount of resources (time and income) agents are available to allocate to social care is proportional to the kinship proximity between them and the person receiving care.
   ii. The share of income households allocate to social care is an increasing function of the households' income.
   iii. The decision about which resource between time and income to use to provide for social care depends on the resources' relative availability.
   iv. Agents with a higher care need (supply) have a higher probability to receive (deliver) social care.
   v. An agent with potential care supply must live close enough to the person with care need to provide informal child and social care.
   vi. Households with childcare needs will allocate their resources preferentially to it before providing social care.
   vii. Households will tend to allocate time to the most expensive kind of care and income to the least expensive kind of care.
   viii. When allocating income to social care, the households will pay for formal social care if the wage of the worker with the lowest hourly wage is higher than the cost of social care, otherwise that worker will provide informal social care by taking hours off work.

b. *Emergence*. The model is not meant to produce any kind of high-level emergent dynamics.

c. *Adaptation*. In the model the agents taking decisions are those providing care. While the amount of informal care supply is fixed, determined by the available time of the agents, working agents can provide additional care by allocating part of their income to this purpose, either by paying for social care or by taking hours off work to provide informal social care. In our model, this choice depends on whether the agents' hourly income is higher or lower than the hourly cost of formal social care. Moreover, the agents decide whether to allocate time or income to the provision of childcare, a choice which depends on the cost of childcare, relatively to the cost of social care. The cost of childcare depends on the number and ages of children, so it changes with time.

d. *Objectives.* The first objective of households is to provide childcare to the household's children. Moreover, households have the objective to provide the maximum amount of social care with the share of income allocated (which is a function of the households' income).

e. *Learning.* Learning is not implemented.
f. *Prediction.* Prediction is not implemented.
g. *Sensing.* All the information the agents need to decide whether to allocate time or income to childcare, work and pay for formal care or take time off work and provide for informal care are assumed to be known by the agents.
h. *Interaction.* In our model, the interaction between agents is dependent on their kinship linkages. There is a direct interaction, represented by the transfer of care to agents needing social care from their relatives with available care supply, and by the transfer of care from the households with care supply to the households with childcare need (including the within-household care provision). Another kind of interaction takes place when agents form partnerships.
i. *Stochasticity.* Our model makes extensive use of stochastic processes to simulate events and behaviours occurring with a specified frequency. Each process in the model has one or more stochastic elements:
    i. *Deaths:* in each period, agents die with a probability which depends on their age, socioeconomic status and frailty (represented by their care need level).
    ii. *Adoptions:* when a child becomes orphan, he/she is adopted by a randomly chosen household with a couple in which at least one partner is working.
    iii. *Births:* in each period, married women give birth, with a certain probability which depends on year, women's age and socioeconomic status.
    iv. *Divorces:* in each period, couples split with a probability which depends on year, men's age and socioeconomic status.
    v. *Marriages:* in each period, single employed men find a partner, with a probability which depends on their age and the children living with them (if any). The partner is stochastically selected among all single women, with a probability which depends on the difference between the man and the women's ages, their geographical and socioeconomic distances, the women's activity status and the women's children living with them (if any).
    vi. *Social transitions:* student above 15 years of age, must decide every two years (i.e., at ages 16, 18, 20 and 22) whether to keep studying or start working, a decision which determine their socioeconomic status. The choice is probabilistic, with the probability to keep studying depending on the income of the student's household, the socioeconomic status of the student's parents and the student's childcare and social care burden.
    vii. *Childcare provision:* in each childcare provision iteration, a household with childcare needs is randomly sampled with a probability proportional to the quantity of childcare needs. Then, in case of high-cost childcare, a household within the care network of the receiving household (including the receiving household) is randomly sampled, with a probability proportional to the amount of informal care supply within that household (amount which depends on the household's structure and the kinship distance). In case of low-cost childcare, the

decision about whether to use informal or formal care is a random choice with probabilities which depend on the relative amount of formal care and the net informal care (i.e., the difference between the total informal care and the household's social care need). In case that informal care is selected, a household within the care network of the receiving household (including the receiving household) is randomly sampled, with a probability proportional to the amount of informal care supply within that household.

viii. *Social care provision:* the provision of social care proceeds through the transfer of 4-hour 'quantum' of social care between a randomly sampled agent with care need and a randomly sampled household in the agent's kinship network. The probabilities to be sampled as a care receiver or a care supplier are proportional to the amount of, respectively, unmet social care need and residual care resources (i.e., time and income) allocated to social care. Moreover, once a care supplier is selected, a stochastic process determines whether time or income will be used to provide for care, a probabilistic choice which depends on the relative availability of the two resources.

ix. *Social care need transition:* each period, agents may move to higher social care needs groups, with a probability which depends on gender, age, socioeconomic status and unmet care need.

x. *Relocation:* married couples decide whether to find a house in the current town of a randomly selected partner or to a town nearby by means of a stochastic process. A worker living with its parents will relocate to another house with a certain probability. Moreover, it will choose a town between the current town and a town nearby by means of a stochastic process. The same stochastic relocation process applies to the case of an adult single. A lone pensioner will relocate into the house of one of its working children with a probability which is inversely proportional to the distance between the lone pensioner's town and the child's town. Finally, a household will relocate with a stochastic process through which it decides whether to remain in the current town or to relocate to a new town. The probability to relocate is directly proportional to the new town' attractiveness compared to the current town's attractiveness (with the towns' attractiveness being an index which depends on the town's housing cost, the towns' SES composition and the towns' 'care attraction factor') and inversely proportional to the cost of relocation. The new town the current town is compared to, is randomly sampled from the list of towns with a probability which is proportional to the product between the town's attractiveness and the town's share of available houses.

j. *Collectives.* In our model, the main actors are the individual agents and households. Apart from the case of the provision of formal social care (where we assume that the social care is procured externally), social care provision takes place between an agent with social care needs and an agent with available care supply. However, the agents' households play an important role, as we

assume that the agents' choices are the result of an implicit negotiation taking place within the agents' households. First, we treat childcare need as an attribute of the household. In both the childcare and social care provision, the probability of a relative being chosen among those in an agent's kinship network, depends on the availability of care within its household, and the agent who provides for care is chosen among the components of the relative's household (including the relative itself). Moreover, the probability that a household provides formal rather than informal care, depends on the relative amount of the household's income allocated to social care. In the relocation process, households decide whether to relocate or not as a collective, with a probability which is inversely proportional to the households' relocation cost. Moreover, the social care attraction of ton is an index which depends on the care need/care supply of the household as a unit.

k. *Observation.* At the end of each period, the data about total childcare and social care need, informal and formal care provided, the government-funded care and unmet care need are collected, for the whole population and for each of the five socioeconomic groups.

5. Initialization.

First, a grid is created representing the UK map. It consists of 12x8 cells, which we call *towns*. For each town, a 35x35 grid is created and a number of houses, proportional to empirical population densities for the UK area represented by the town, is randomly placed in the 1,225 cells of the grid.

Then, a population of males is generated of random age between 24 and 45. For each male, a female partner is created, whose age is the age of its partner minus a number of years sampled in the range (-5, 2). The agents forming a couple belong to the same socioeconomic class, which is randomly sampled. At least one member of the couple must be employed, with a salary which is a function of age and socioeconomic class. Each couple is placed in a random house in the grid representing the UK map and is assigned a number of years of permanence in the house which is sampled in the range (0, 9).

6. Input Data.

The model has four input data:

a. the fertility rates by age from 1951, from the Birth Statistics of the Office for National Statistics of the year 1998.
b. The mortality rates by age and gender from 1951, from the Human Mortality Database 2011.
c. The Local House Allowances (LHA) by house size.
d. The percentile points of the UK wealth distribution in 2015.

7. Submodels.

a. For each agent, a probability of death is computed. The input is the mortality rate for the agent's age. The agent's variables which define the agent's specific death probability are: the agent's socioeconomic status; the agent's care need level and the share of social care need which is unmet. First, with the age-

specific mortality rate we find the SES-specific mortality rate, by setting a mortality rate's socioeconomic bias (which is a parameter determining by how much the mortality rate increases as we go from a SES to a lower SES). Then we find the social care need-specific mortality rate, by setting a mortality rate's social care need bias (which is a parameter determining by how much the mortality rate increases as we go from a social care need level to a higher social care need level). The agent will die according to this mortality probability and will be eliminated from the population. The state of the partner will be set to 'single' and if the agent had children but no partner, the state of the children is set to 'orphans', to be relocated to another household.

b. Children whose parents with whom they were living died, move with the other parent or, if orphans, are assigned a new family among married couples where at least one partner is working. Students whose parents with whom they were living died, move with the other parent or, if both their parents died, they start working, while remaining in their current house.

c. The agents' social care level is updated. In our model, agents don't recover, so with a certain probability they will move to a higher social care level than their current one. The process proceeds in two steps. In the first step, with a certain probability each agent will increase its social care need level. In the second step, the size of the increase will be determined. As for the first process, the probability of an agent experiencing an increase of its care need level is given by an age, gender and SES-specific probability multiplied by the exponential of the product of a parameter with the average of the agent's share of unmet care need (the assumption being that if an agent has a high level of unmet care need over many periods, its conditions will tend to get worse). To determine the age, gender and SES-specific probability of care transition, first the age and gender-specific probability is computed as the sum between a parameter which represents a base transition rate and a factor given by the product between a parameter and the exponential of the product between the agent's age and a gender-specific parameter. Then, with this transition rate and a parameter representing how the transition rate decreases as we increase the SES by one level, and knowing the SES shares in the population, we determine the SES-specific transition rate for that age and gender class. If the agent witnesses an increase of its social care need level, a transition rate is define as the product of the exponential of the product of a parameter with the average of the agent's share of unmet care need and 1 minus the SES-specific transition rate, where the SES-specific transition rate is calculated with a parameter representing the average transition rate and a parameter representing how the transition rate decreases as we increase the SES by one level. Then, a cycle is started with a probability ρ equal to the SES-specific transition rate s and continues with probabilities which get increasingly small at each cycle, by means of the equation $\rho_t=(1-\rho_{t-1})s$. The number of iterations determine the number of levels the agent's social care need level is increased (up to a maximum of 5).

d. The social care need for the period, of each agent with a care need level higher than zero, is determined and the amount of public social care (if any) is computed and subtracted from the agent's total social care need. In line with the

UK social care policy, there are age, social care need and wealth thresholds to get public social care. In these conditions are met, the agent with care need will receive a public support for the amount exceeding the social care that the agent can buy with its income, less a minimum income guarantee amount. If the agent has a wealth above a certain amount, the public social care contribution will be reduced by one pound for every 250 pounds of its wealth.

e. For the agents with care need, the amount of financial wealth allocated to social care in the period is computed. It is given by the product of the share of wealth allocate to social care and the ratio between the agent's financial wealth and the agent's life expectancy. The share of wealth allocated to social care is given by 1 minus the reciprocal of the product of a parameter for the agent's financial wealth (therefore, the higher the agent's wealth the higher the share of wealth allocated to social care).

f. The childcare need for each child is computed. We assume that children (i.e., agents between age 0 and age 11), have a total childcare need of 56 hours per week. The childcare need of new-borns is provided entirely by their mothers, and therefore have a 0 net childcare need. Children between age 1 and age 11 have a net childcare need which depends on the public childcare, which in turn depends on the households' income. Additional childcare is provided through public education. Once the total net childcare needs of each household have been computed, the household's childcare is divided into groups of childcare needs of different costs. First, we order the individual childcare needs from the lowest to the highest. The determination of the groups of different cost, is shown in the following example, for a household with 4 children with childcare needs of 9, 9, 15 and 18 (for expository convenience, each cell represents 3 hours of need):

<table>
<tr><th>Child 1</th><th>Child 2</th><th>Child 3</th><th>Child 4</th><th>Groups</th><th>Hours</th><th>£/Hour</th></tr>
<tr><td></td><td></td><td></td><td></td><td>III</td><td>3</td><td>5</td></tr>
<tr><td></td><td></td><td></td><td></td><td rowspan="2">II</td><td rowspan="2">12</td><td rowspan="2">10</td></tr>
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<tr><td></td><td></td><td></td><td></td><td rowspan="3">I</td><td rowspan="3">36</td><td rowspan="3">20</td></tr>
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The cost of each group is given by the number of children of each group multiplied by the hourly price of childcare, which is set to £ 5. The reason of this grouping operation is that differently from social care, we assume that one carer can provide care to more than one child at a time. For example, an informal carer providing 3 hours of care to Child 1, will at the same time provide 3 hours of care to the other three children. However, should the household pay for formal care, the total cost of childcare would be the cost of 3 hours times 4 (i.e., the number of children). Therefore, when deciding whether is more convenient for the household to pay for formal care or to provide informal care, the cost to consider is the hourly cost of formal childcare multiplied by the number of children who have 1 hour of residual childcare need. Once we have grouped the household's childcare needs in this way, we calculate the *high-cost childcare*

and the *low-cost childcare* of the household, the threshold being the cost of formal social care. Therefore, setting the cost of formal social care to £ 17/hour, the household in the example will have 36 hours of high-cost childcare (i.e., Group I, whose cost per hour is £ 20), and 15 hours of low-cost childcare (Group II and Group III).

g. The supply of informal care which of each agent at care need level zero, and the total household's income of each household (which represent the financial resources to provide for childcare), are updated. Each healthy agent can provide a certain number of hours according to whether it is a teenager, a student, a retired agent or a worker. New mothers (i.e., women who gave birth in the current year) will need to dedicate all their time to the new-born, and therefore will not be able to supply any social care. We assume that for legal and cultural reason, there cannot be unmet childcare needs, so, differently from the case of social care need, the households allocate all their income to childcare, if they have to. Therefore, the household's income determines the maximum amount of formal childcare the household will be able to provide to satisfy the childcare need of children *within* the household. We assume that no formal childcare is supplied by other households.
h. For each person with care needs, the kinship network for the period is created. The network, connects the person with care need with the members of its households and relatives living in other households, with links whose weights being as follows:
    i. 0 for the links with the other members of the person's household.
    ii. 1 for father, mother and children living in other households.
    iii. 2 for grandparents, grandchildren and brothers living in other households.
    iv. 3 for aunts, uncles and nephews.

    Moreover, for each household a *care supply network* and a *care demand network* are created. The care supply network is created in the same way the kinship network is created for the agents with social care need, except that now the link is created between a household and the households where the closest relatives with any of then household's members live. The care demand network is created by linking a household and the households the care supply network of which it is part of.
i. The households' *net care demand* is computed. It represents the difference between the household's total need (i.e., childcare needs plus social care needs) and the household's total informal care supply. It can be negative, if the household's supply exceeds the household's total need.
j. The childcare provision loop starts. At the beginning, the *total childcare supply* each household can count on is computed. It is given by the sum of the informal and formal childcare supply of the household itself plus the informal childcare the household can receive from the other households which are part of its care supply network, according to their kinship distance and on the condition that they live in the receiving household's town (i.e., we assume that informal care can be transferred only between agents living in the same town).

k. At each iteration of the childcare provision loop, a childcare-receiving household is randomly sampled with probabilities proportional to the amount of unmet childcare need. In each iteration, there are two possible cases:
    i. The household has residual *high-cost childcare*.
    ii. The household has only *low-cost childcare* left.

    In the first case, the household will try to satisfy childcare with informal care. In the household can count on residual informal care, a supplier will be randomly chosen among the household's suppliers with a probability proportional to the supplier's informal care availability. The members of the randomly sampled supplying household will be ordered by amount of available informal care and starting from the member with highest informal care availability, the minimum between a 4-hour quantum of care and the supplying household total informal care availability will be transferred from the members of the supplying household to the children of the receiving household. However, if there is no informal care left within the household's network, the household will use its income to provide for childcare. There are two possible cases:
    a. the wage of the household's working member with the lowest wage is *higher* than the cost of childcare (as determined above, at point *f*);
    b. the wage of the household's working member with the lowest wage is *lower* than the cost of childcare.

    In case *a*, the household will be better off paying for formal childcare. The first source of income used is that generated by not working members (such as, members who retired). If this source is not enough to satisfy all the childcare need, the income generated by working members must be tapped. In this case, the households' workers will be ordered by descending hourly wages and starting from the worker with the *highest* wage, the number of working hours needed to pay for a 4-hour quantum of care will be set aside. In case *b*, it is more convenient for the household that the worker with the lowest hourly wage takes hours off work to provide informal care, so this worker will take 4 hours off work to provide for informal childcare (or all its remaining working hours, if less than 4). Note that, because of the *one-to-many* nature of childcare (see point *f* above) in case informal care is provided, the childcare need of *all* the children in the receiving household will decrease by the amount of care provided, while in case the household pay for formal care, the care provided will reduce the childcare need of one child at a time (starting from the one with the highest unmet care need).

    If the household has only *low-cost childcare*, it will be more convenient for the household to pay for formal childcare and leave the informal care for the more expensive social care provision. However, if the household has enough informal care for both kind of care, the informal care will be provided with a probability which is proportional to the ratio between the difference between the total informal care the household can count on and the household's social care need, and the total care, given by the sum between the total informal care the household can count on and the household's available formal care. The probability that the childcare will be provided out of the household's income is

1 minus the probability of informal care. The childcare loop will end when there isn't any household with residual childcare with available care supply.

l. The social care provision process starts. First, each agent with care needs computes the amount of total social care it can count on, given by the sum of the available informal care and the formal care it can buy with the wealth it allocated to social care and the income that its household and the households with kinship distance equal to 1 allocated to social care.

m. The social care provision loop starts. In each iteration, an agent is sampled from the population of agents with unmet social care need with available supply with a probability proportional to the agents' unmet care need. Then, a care supplier is randomly sampled among all the suppliers of the sampled receiving agent, including itself, with a probability proportional to the care supply each supplier can provide (which in the case of the agent receiving care is determined by the share of financial wealth it allocates to social care). If the sampled care supplier is the care receiver itself, the wealth allocated to social care is used to buy a 4-hour quantum of formal social care, with the reduction of both the available wealth and the agent's unmet social care need. On the other hand, if the supplier is another agent living in another town, the social care provided could only be out-of-income care (i.e., formal or informal care supplied by using the share of income allocated to social care). In this case, the first source of income used is that generated by not working members (such as, members who retired). If this source is not enough to satisfy all the social care need, the income generated by working members must be tapped. In this case, the households' workers will be ordered by descending hourly wages and starting from the worker with the *highest* wage, the number of working hours needed to pay for a 4-hour quantum of care will be set aside. On the other hand, if care receiver and care supplier live in the same town, both informal and out-of-income social care can be supplied, the choice being determined by a random draw with probabilities proportional to the relative amount of the two kinds of care. In case the supplying household uses income to provide for social care, there can be two cases:

    i. the wage of the household's working member with the lowest wage is higher than the cost of social care;
    ii. the wage of the household's working member with the lowest wage is lower than the cost of social care.

    In case *i*, it is more convenient for the household to buy formal care. The first source of income used is that generated by not working members (such as, members who retired). If this source is not enough to satisfy all the social care need, the income generated by working members must be tapped. In this case, the households' workers will be ordered by descending hourly wages and starting from the worker with the *highest* wage, the number of working hours needed to pay for a 4-hour quantum of care will be set aside. In case *ii*, it is more convenient for the household that the worker with the lowest hourly wage takes hours off work to provide informal care, so this worker will take 4 hours off work to provide for informal social care (or all its remaining working hours, if less than 4).

Finally, if informal social care is provided, the members of the supplying household will be ordered by amount of available informal care and, starting from the member with highest informal care availability, the minimum between a 4-hour quantum of care and the supplying household total informal care availability will be transferred from the members of the supplying household to the social care receiver.

n. The age of the agents and, eventually, their status is updated. The children will become teenager at the age of 12 and teenager become adult at the age of 16 (age at which they must decide whether to keep studying or start working, see point *q* below). At the age of 65 agents retire. Women whose child passed from 0 to 1 year of age, become students if they have years of education left, otherwise enter the workforce.
o. Each year, all married women of age 17 to 42 give birth with a probability which depends on their age and their socioeconomic status. Given the age-dependent fertility rate, the SES-dependent fertility rate is determined by the share of that SES in all the age-specific set of potential mothers and a parameter determining how much the fertility rate grows as we go from a SES to a lower SES. Given that the input fertility rare is computed considering all the female population and in our model only the married women can give birth, the final birth probability is obtained by dividing the SES-specific fertility rate for the share of married women in the woman's age-SES group. In case a woman gives birth, a new agent is created and is added to the members of the woman's household. The new agent is added to the list of children of the woman and its partner.
p. The hourly wage of the working agents is updated, considering the growth of their working experience. Their actual income is updated considering their working hours, which is 40 minus the hours they eventually took off work to provide for informal social care. The income of agents who retire in the current period is computed, as a share of their last working income, equal to the ratio between the number of years they have worked, and the minimum number of years needed to get the full pension (which is set to 35 years of work). The period income (i.e., the income net of the social care expenses) is added to the cumulative income, which is then used to assign the agent a *wealth*, which is the wealth associated with the agent's cumulative income percentile.
q. At the age of 16 years, agents become students, with a probability which is the product of three factors which can take values between 0 and 1:
    i. An income factor which is given by the ratio between a parameter and the sum between the parameter and a measure of the cost of continuing education, given by the exponential of the product between a parameter and the ratio between the foregone salary for continuing in education and the average income of the agent's household.
    ii. A family education factor which is given by the ratio between the exponential of the product of a parameter with the difference between the agent's parents education level and the agent's current education level and the sum between a parameter and the exponential of the product of a parameter with the difference between the agent's parents education level and the agent's current education level.

iii. A care work factor given by the inverse of the exponential of the product of a parameter with the amount of the agent's social and childcare provision.

If the agent quits education, it enters the workforce, while if it remains in education, the choice is repeated after two years, until it reached the age of 24 years, when the agent reaches the highest socioeconomic status and enters the workforce.

r. For each couple, the probability of divorcing is computed. The input is an age-specific men's divorce rate, which is multiplied by a parameter to get a base rate. Then the SES-specific divorce rate is computed, with a parameter determining how the probability of divorce decreases as the agent's SES increases. With this probability, the couple splits, the man relocates to another house and the partner remains with their children in the current house (unless the children are the natural offspring of the male but not of the female, in which case they move with the father). If the woman was a student, she starts working.

s. Single working men become married with a probability which is the product of a constant parameter and an age-specific marriage rate. Moreover, we assume that within each age group, men with children have a lower probability to get married than men without children, by a factor $\tau<1$ which is a parameter of the model. For each man to marry, a woman is selected among the single women above the minimum reproduction age who are not relatives of the man. The relative probability associated with each woman is the result of the product of five factors:
   - *i.* A dummy variable taking the value of 1 if the woman is not a student and $\beta < 1$ if the woman is a student.
   - *ii.* The inverse of the exponential of the normalized geographical distance between the woman and the man, multiplied by a parameter.
   - *iii.* The inverse of the exponential of the normalized socioeconomic distance between the man and the woman, multiplied by a parameter μ if the man's SES is higher than the woman's SES and a parameter $\theta<\mu$ if the man's SES is lower than the woman's SES.
   - *iv.* A parameter whose value depend on the difference between the age of the man and the age of the woman.
   - *v.* The inverse of the exponential of the product between the number of children living with the woman and a parameter.

t. Partner living in different houses are joined. If living in a different town, a town is randomly sampled with equal probabilities between the partners' current towns. Then, by means of another random choice, the couple (and their children, if any) find a house in the sampled town or in a town nearby. Working adults living with their parents and single adults relocate to another house in their current town or a nearby town with a probability which is given by the product between a base rate and an age-specific rate. Lone retired agents will move in one of their children's households (if any), with a probability that is given by the ratio between a parameter and the distance between the town of the retired agent and the towns where its children live.

u. In each period, households relocate to other towns with a certain probability. This stochastic relocation process unfolds in two steps:
    i. A town other than the household's current town is randomly sampled;
    ii. The household decides whether to move to the sampled town or remain in its current house.

    In stage *i*, a town is sampled from the set of all towns with a probability which is proportional to the product between the towns' share of available houses and the towns' *attractiveness*. A town's attractiveness is the product of three factors: a *care* factor, a *social* factor and an *economic* factor. The determination of the care factor starts with the computation of the households' *care dependence index* (CDI). The CDI is a measure of the degree to which then household depends on its care network for the provision of its care needs. It is given by the difference between the household's total care need (that is, the sum of the childcare need and the social care need) minus the household's total informal care availability. If the difference is positive (i.e., the household is a net receiver of informal care), it is divided by the exponential of the product between a parameter and the household's income per capita (the assumption being that the higher the household's income, the smaller its dependence on informal care). Then, for each town, the household computes the town-specific network pull index (NPI), which is a measure of the relevant care associated with the households which are part of its care supply or care demand network living in that town. In case of positive CDI, the relevant network is the care supply network. Therefore, a list of all suppliers with negative CDI (that is, with net informal care supply) is created and the weighted sum of the absolute value of these households' CDIs is computed. The weights are the reciprocal of a parameter $\phi<1$ to the power of the households' kinship distance. In case of negative CDI, the relevant network is the care demand network. Therefore, a list of all receivers with positive CDI (that is, with net informal care need) is created and the weighted sum of the absolute value of these households' CDIs is computed. The care factor is the exponential of the product between the absolute value of the household's CDI, the town-specific NPI and a proportionality parameter. The social factor is a measure of the affinity between the social composition of the town and the household's SES and is given by the exponential of the product between a parameter and the difference between the town-specific *SES affinity* and the national SES affinity. The town-specific SES affinity is represented by the share of same-SES households living in a town. Finally, the economic factor represents a measure of the towns' affordability, and it depends on the households' income per capita. First, the size of the household's house is computed as a function of the number of household's members and their ages. The *relative affordability* of a given town is given by the local housing allowance (LHA) for that size divided by the exponential of the product of a parameter and the household's income per capita. The economic factor is the reciprocal of the exponential of the product of a parameter and the town's relative affordability. Once a town has been randomly sampled, the *attractiveness ratio* of the new town compared to the current town is computed as the ratio between the attractiveness of the new town and the sum of the new

town's attractiveness and the current town's attractiveness. The probability of relocating to the new town is given by the product between the attractiveness ratio, a scaling factor and the reciprocal of the household's *relocation cost factor*. The household's relocation cost factor is given by the exponential of the product between a parameter and then household relocation cost, which is the sum of the relocation cost of each household's member. The relocation cost of a household's member is given by the number of years that member has been living in the current town to the power of a parameter.