“A mitigation tool to protect a home health care structure facing a hydrological disaster”

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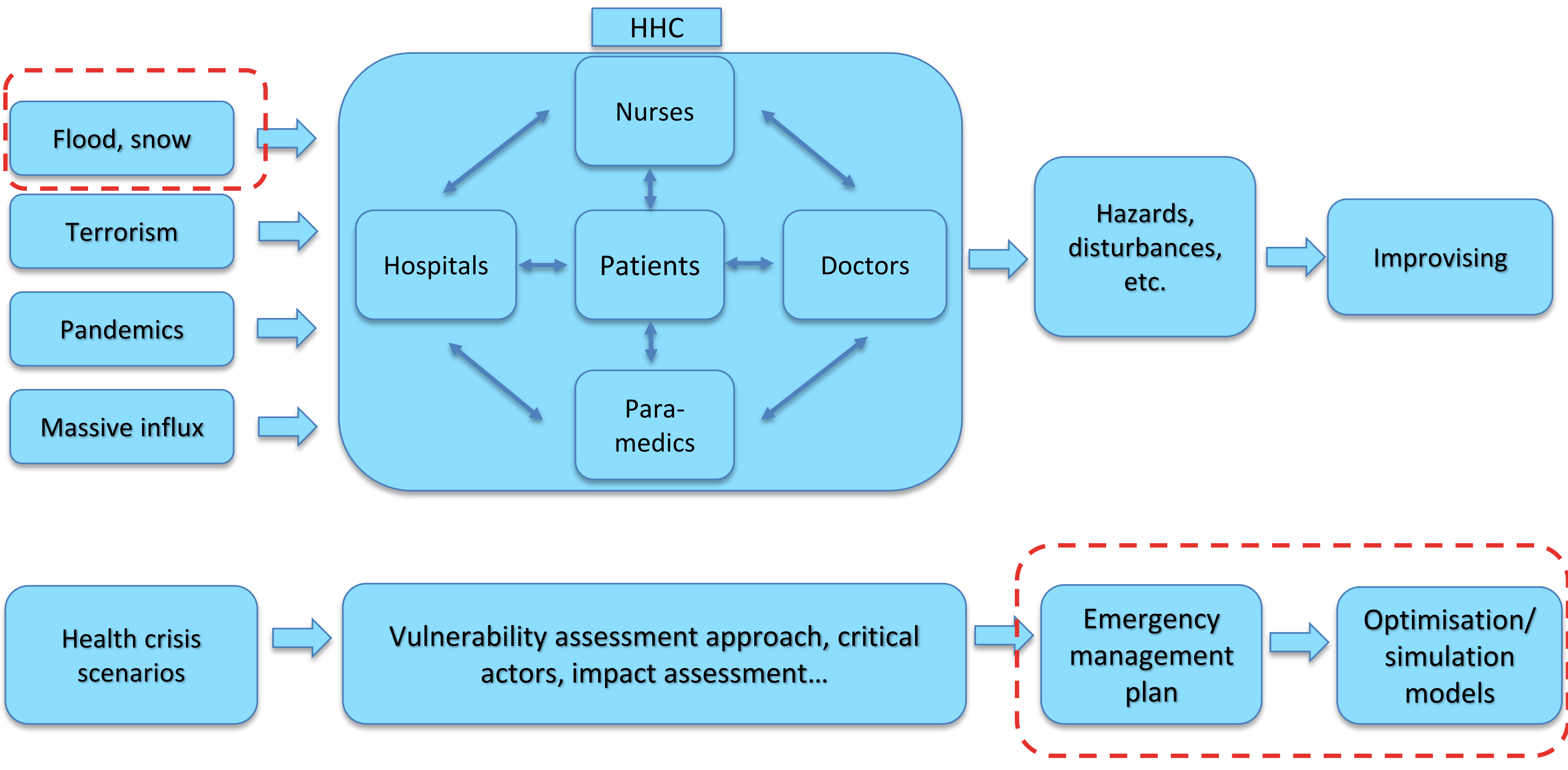
Agenda

- Context
- State of the art
- Mitigation model
- Prospects

Context


HHC
Flood, snow
Terrorism
Pandemics
Massive influx
Nurses
Hospitals
Patients
Doctors
Para-medics
Hazards, disturbances, etc.
Improvising
Health crisis scenarios
Vulnerability assessment approach, critical actors, impact assessment…
Emergency management plan
Optimisation/ simulation models

State of the art

Evacuation problem

Optimization models

Macroscopic evacuation:
Endangered area evacuation,
location-allocation, BEP,etc.
Song et al. (2009), Tayfur and Taaffe (2009), etc.

Simulation models

Microscopic evacuation:
evacuation of buildings
(Pelechano and Malkawi, 2008), (Kaup and al. 2002), etc.

➔ the optimization models are the most suitable when considering evacuation problem with resource distribution.

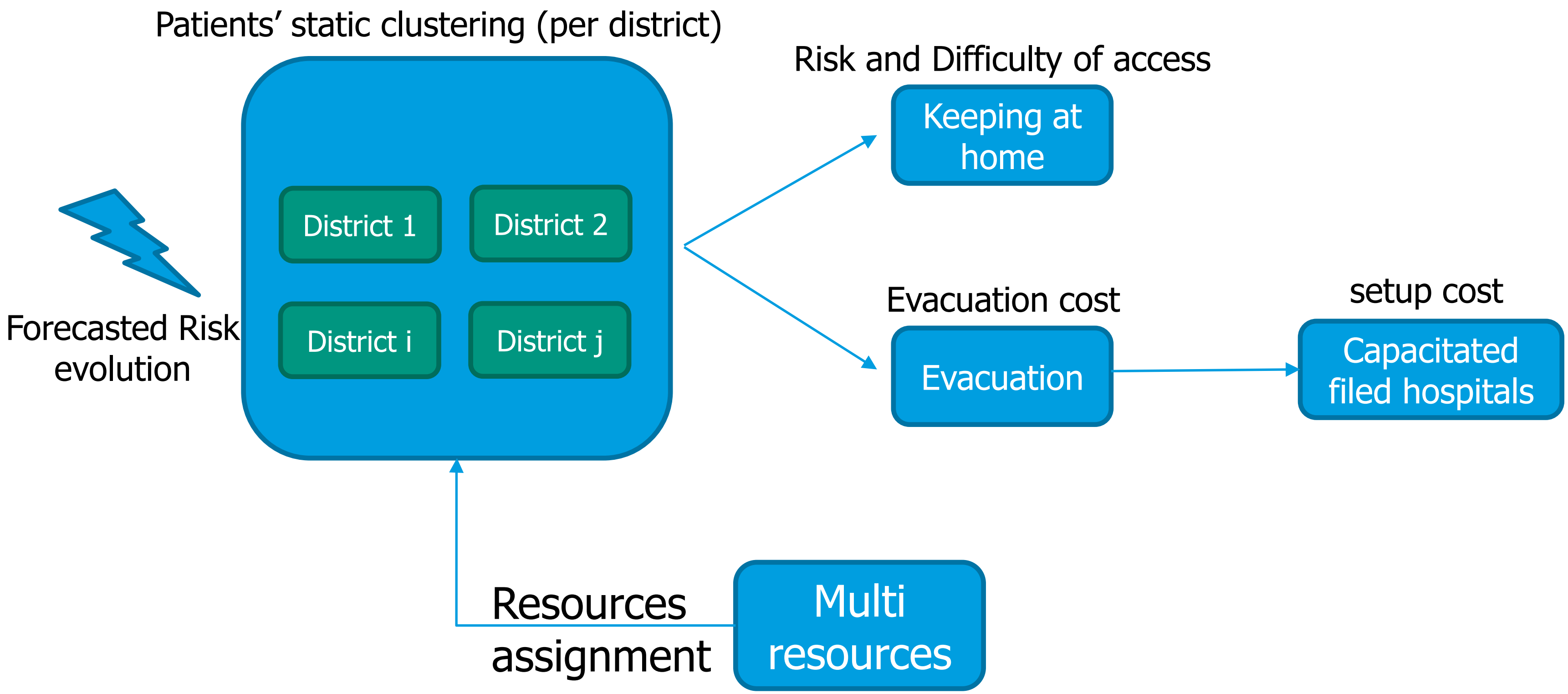
State of the art

- Our model is based on a real life scenario which has been defined with our partner: Soins et Santé. Therefore the model is well suited to the Home Health care practices.

- The improvement methods that we propose can be easily applied in the field.

- Our attention is focused on the patient evacuation and resource assignment.

Evacuation model



Evacuation model

- Data:
  - M: number of areas,
  - T: number of studied periods,
  - N: number of type of resources (doctors, nurses, etc.),
  - K (i): number of resources of type i,
  - Cap (h, i): capacity of resource h of type i per period,
  - Wei (j): number of patients per area j,
  - Evol (i,j,p): evolution rate for the accessibility of area j for the resource i on period p,

Evacuation model

- Forecasted crisis modelling (Evol (i,j,p)):

Period/ District	24 Jan	25 Jan	26 Jan	27 Jan	28 Jan	29 Jan	30 Jan	31 Jan	1 Feb	2 Feb
Area 1	0	0	0	0	0	0	0	1	-1	0
Area 2	0	0	0	0	1	1	1	1	-1	-1
Area 3	0	0	0	0	0	0	1	1	-1	-1
Area 4	0	0	0	0	0	0	0	0	0	0
Area 5	1	1	1	1	1	1	1	1	-1	-1
Area 6	0	0	0	0	0	0	1	1	-1	-1
Area 7	0	0	0	1	1	1	1	1	-1	-1

- Number of patients per area (Wei (j)):

Area/district	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7
Number of patients	10	30	20	40	20	30	10

Evacuation model

- Data:
  - Homecost (h,i,j):employment cost of one resource h of type i, for the area j,
  - Evacost: evacuation cost of one patient to a hospital,
  - HV: High value (999,999).

- Decision variables:
  - Acces (i,j,p): real variable, accessibility of area j using a resource of type i (i.e. liberal nurse or salaried nurse) during the period p,
  - X (h,i,j,p): integer variable, quantity of resource h of type i used in area j during the period p,
  - Y (j,p): binary variable, it is equal to 1 if the area j is evacuated during the period p, 0 otherwise.

Evacuation model

- Objective function:

$$Minimiser\,(Z) = \sum_{i=1}^{N}\sum_{h=1}^{K(i)}\sum_{j=1}^{M}\sum_{p=1}^{T}\big(X\,(h,i,j,p) * Homecost\,(h,i,j)\big) + \sum_{j=1}^{M}\sum_{p=1}^{T}(Y\,(j,p) * Wei(j) * (Hospcost * (T-p+1) + Evacost)) \quad (1)$$

➔ We seek to minimize on one hand the visiting costs of patients in non-evacuated areas, and on the other hand the evacuation and hospitalization costs of patients in evacuated areas.

Evacuation model

- **Constraints:**
- $Acces\,(i,j,1) = 1 \quad \forall\, i, \forall j \quad (2)$
- $Acces\,(i,j,p+1) = Acces\,(i,j,p) + Evol\,(i,j,p) \quad \forall i, \forall j, \forall p < T \quad (3)$
- $\sum_{p=1}^{T} Y\,(j,p) \leq 1 \quad \forall\, j = 1, \dots, M \quad (4)$
- $\sum_{h=1}^{K(i)} X\,(h,i,j,p) \geq Wei(j) * Acces\,(i,j,p) - \left(\sum_{q=1}^{p} Y\,(j,q)\right) * HV \quad \forall i, \forall j, \forall p \quad (5)$
- $\sum_{j=1}^{M} X\,(h,i,j,p) \leq Cap\,(h,i) \quad \forall i, \forall h, \forall p \quad (6)$
- $\sum_{j=1}^{M} \sum_{p=1}^{T} Y\,(j,p) * Wei\,(j) \leq NBeds \quad (7)$

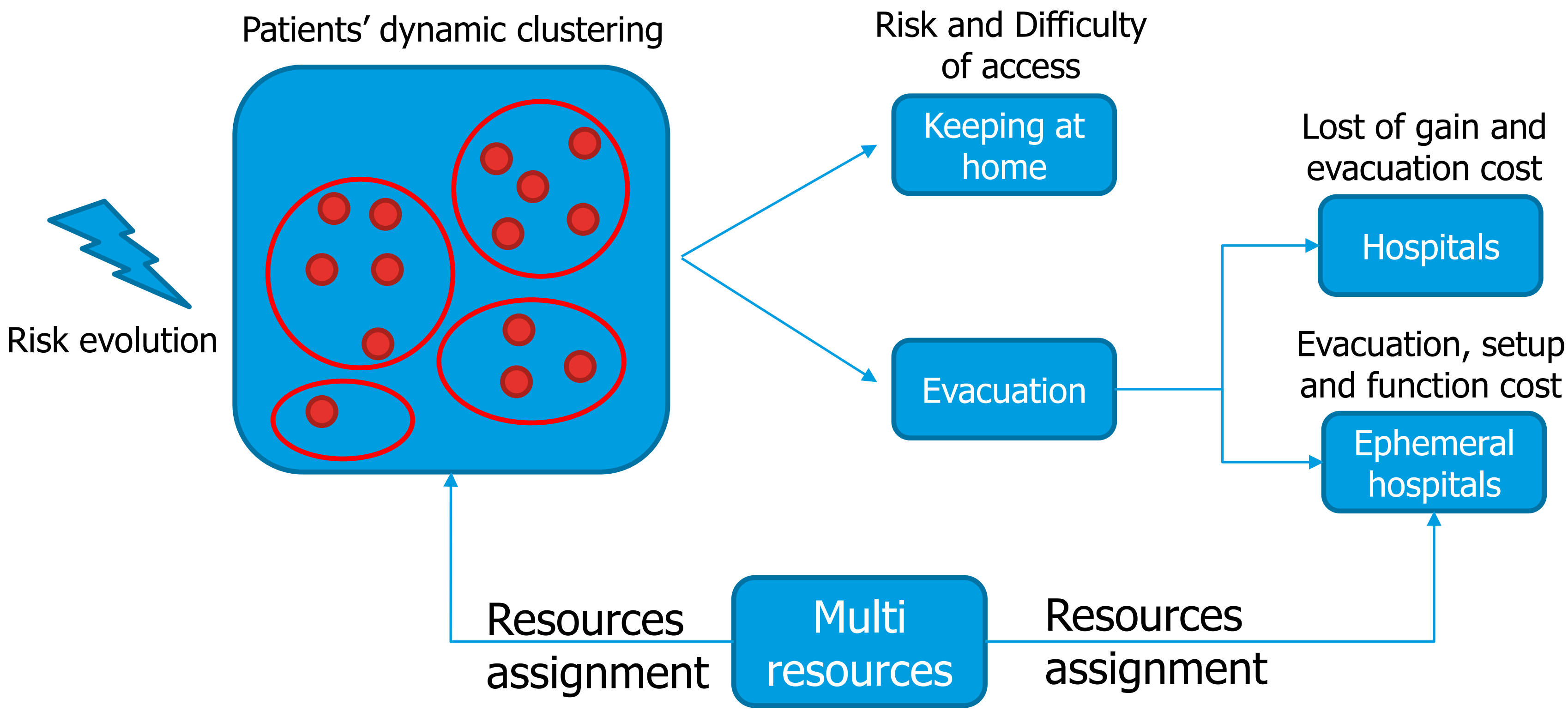
Evacuation model

- Results (Cplex 12.6.2)

Period	23 Jan	24 Jan	25 Jan	26 Jan	27 Jan	28 Jan	29 Jan	30 Jan	31 Jan	1 Feb
Area 1	10	10	10	10	10	10	10	10	20	10
Area 2	30	30	30	30	30	60	90	120	150	120
Area 3	20	20	20	20	20	20	20	40	60	40
Area 4	40	40	40	40	40	40	40	40	40	40
Area 5	20	40	60	80	100	120	0	0	0	0
Area 6	30	30	30	30	30	30	30	60	90	60
Area 7	10	10	10	10	20	30	40	50	60	50
Total	**160**	**180**	**200**	**220**	**250**	**310**	**230**	**320**	**420**	**320**

- Solution cost: 202 200 €
- Home care cost: 160 200 €
- Evacuation cost: 32 000 €

Prospects



➔ Dynamic Partitioning Problem combined with an assignment problem

Thank you!

Do you have any questions?

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