Table 2: Summary of Model Variables, Parameters, and Simulation Settings

Symbol	Definition/Description	Value/Range	Rationale and Role
L_d	Cellular space: 2D lattice representing the employee population in a smart manufacturing enterprise.	50×50 (2,500 cells)	Approximates a medium-to-large smart manufacturing facility (Ghahramani et al., 2020). Balances representational validity and computational tractability. Used to define the simulation grid.
S	Discrete awareness state set: Low (0), Intermediate (1), High (2) AI data security awareness.	$\{0, 1, 2\}$	Tripartite structure captures nonlinear state transitions specific to AI contexts, grounded in behavioral safety taxonomies (Bellamy et al., 2008; Sebescen and Vitak, 2017). Defines agent states in the CA model.
S_v	Continuous awareness evaluation value: Latent score reflecting intra-state variability.	Uniform randint[0,99]	Represents natural heterogeneity in employee preparedness (Reb et al., 2013). Evolves dynamically based on interactions, decay, and interventions. Initialized uniformly for simulation.
S_o^t	Overall awareness level at time t: Sum of all S_v values across the grid.	$\sum S_v$	Macro-level metric for intervention effectiveness, rooted in SCT's emergent collective outcomes (Bandura, 1988). Tracked over 100 iterations to assess simulation outcomes.

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Symbol	Definition/Description	Value/Range	Rationale and Role
$N_{(i,j)}$	Neighborhood structure: Hexagonally adjacent cells to (i, j), simulating workplace peer groups.	6 neighbors, $\omega_k = 1/6$	Models isotropic social influence, mitigating directional bias of square lattices. Aligns with typical team sizes (5–7 members) in smart manufacturing (Nugraha et al., 2020). Defines peer interactions in the CA model.
$P^t_{(i,j)}$	Local data security climate: Weighted average awareness state of neighbors.	$\sum \omega_k S^t_k$, $\omega_k = 1/6$	Operationalizes SCT's observational learning (Bandura, 1988). Equal weights assume symmetric peer influence (Han et al., 2020). Influences dynamic thresholds in the CA model.
δ	Awareness decay factor: Models complacency or knowledge forgetting.	0.1	Calibrated to 10% monthly decay in safety knowledge retention (Jaiswal et al., 2021). Applied at each of the 100 simulation iterations to model natural awareness decline.
α	Sensitivity parameter for low-to-intermediate threshold: Adjusts T_1 based on local climate P.	0.5	Determined via grid search [0.3,0.7]. Reflects strong peer influence on foundational awareness (Han et al., 2020). Governs T_1 in state transitions.
β	Sensitivity parameter for intermediate-to-high threshold: Adjusts T_2 based on local climate P.	0.3	Determined via grid search [0.1,0.5]. Reflects higher cognitive barriers to AI security mastery (Jaiswal et al., 2021). Governs T_2 in state transitions.

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Symbol	Definition/Description	Value/Range	Rationale and Role
$T_1(P)$	Dynamic threshold for low ($S = 0$) to intermediate ($S = 1$) awareness transition.	$50 - \alpha P$	Baseline of 50 reflects cognitive threshold for basic AI security literacy (Jaiswal et al., 2021). Dynamic component models peer influence per SCT (Bandura, 1988).
$T_2(P)$	Dynamic threshold for intermediate ($S = 1$) to high ($S = 2$) awareness transition.	$80 - \beta P$	Baseline of 80 reflects cognitive leap for AI security mastery (Deng et al., 2024). Dynamic component captures peer influence effects.
I^t	Management intervention effect at time t: Modifies S_v based on scenario (none, mild, mandatory).	Varies by scenario	Represents SCT's environmental factor (Wood and Bandura, 1989). Mild: 10% of agents, S_v+randint$[5, 10]$; Mandatory: 20% of agents, S_v + randint$[10, 20]$. Applied per iteration.
η	Intervention efficiency: Ratio of awareness gain to relative cost.	$\Delta S_o / C_I$	Cost-benefit metric for intervention effectiveness (Chen, 2024). Evaluates simulation outcomes across scenarios.
C_I	Relative intervention cost: Normalized measure of resource demand.	1 (mild publicity), 2 (mandatory training)	Mandatory training is twice as resource-intensive as publicity (Chowdhury and Gkioulos, 2021). Used to compute η in simulation analysis.
Simulation Duration	Number of iterations per simulation run.	100 iterations	Sufficient to observe stable, long-term trends in awareness evolution. Determined through preliminary testing.

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Symbol	**Definition/Description**	**Value/Range**	**Rationale and Role**
Initial State Distribution	Initial proportions of awareness states.	30% ($S = 0$), 40% ($S = 1$), 30% ($S = 2$)	Models baseline heterogeneity in employee preparedness (Reb et al., 2013). Randomly assigned spatially at $t = 0$.
Replications	Number of independent simulation runs.	50	Mitigates stochastic variability and ensures statistical stability of results.