中文摘要

傳染性疾病之全球負擔與人類行為具顯著之相關性。近年，針對改變人類行為以達預防疾病和減輕疫情上，風險感知扮演關鍵性作用。因此，藉由量化風險感知及人類行為改變對傳染病傳輸網絡之影響具重要性。

本論文之研究目的為（1）於季節性流感期間，進行問卷調查，以量化特定年齡之風險感知及行為改變反應、（2）在疾病族群動態下，以一行為—流感模式（behavior-influenza model），評估風險感知散佈及流感傳染力間之相互作用、（3）在流感傳輸網絡，以訊息理論結合行為—流感模式、網絡行為—流感模式（network behavior-influenza model），評估風險感知散佈之訊息量、（4）以機率感染風險模式（probabilistic infection risk model），預測流感感染風險、及（5）使用行為改變模式（behavior change model），評估健康行為改變對控制效果之衝擊。

本研究分別在季節性流感前（調查 1）和期間（調查 2），進行風險感知及健康行為問卷，以提供特定年齡和區域之風險感知及行為反應資訊。問卷分析所得之風險感知散佈率估計值則將結合行為—流感傳輸網絡模式。此外，結合行為—流感模式及網絡行為—流感模式以建構行為—流感傳輸模式，其中，選擇無訊息瓶頸之網絡行為—流感（NM-I）模式及訊息瓶頸之網絡行為—流感（NM-II）模式作為兩種網絡行為—流感模式，以闡述於季節性流感前及期間風險感知及行為改變對流感傳輸網絡之衝擊。再利用機率感染風險模式，以評估隨風險感知之健康行為改變對感染風險影響。再者，以感知為基礎之傳輸模式結合至健康行為改變模式，以評估特定年齡健康行為改變之影響。最後，利用負回饋控制模式結合人類實驗性之流感資料，以評估接種疫苗及抗病毒藥物之控制效果。

針對調查 1 及調查 2 之問卷分析結果顯示（1）受測者感知自我風險程度高於基於政府及科學文獻之訊息來源、（2）年齡 10 – 19 及 25 – 34 歲之年輕受測者在高比例之感知分數分佈上高於年齡 20 – 34 歲、及（3）年齡 10 – 19 及大於等於 45 歲具有個人衛生、藥物使用及社會距離之健康行為改變。

另一方面，行為—流感傳輸網絡模式之模擬結果顯示（1）調查 1 之風險感知散佈率低於調查 2 之風險感知散佈率、（2）在網絡行為—流感模式，隨透過個人接觸次數之有效訊息，最大風險感知互訊息（MI_{max}）隨風險感知之信息量之增加而增加、及（3）以 NM-I 模式推導之 MI_{max} 估計值則低於 NM-II 模式。

行為改變模擬之結果指出（1）藥物使用及社會距離之健康行為改變具有較低感染風險機率、（2）於季節性流感 A/H1N1 下，以病毒藥物之控制行為，其 MI_{max} 估計值為 3.1 bits、於季節性流感 A/H3N2 下，無任何控制措施，其 MI_{max} 估計值為 2.9 bits、及於季節性流感 type B 下，以接種疫苗之控制行為，其 MI_{max} 估計值為 3.2 bits、及（3）以病毒藥物之控制行為具有顯著之最大風險感知互訊息改變量。

本研究之結論為（1）受測者依據自身之流感知識則感知較高之自我感染機率程度高於依據政府及科學文獻作為訊息源、（2）青少年具有顯著之健康行為改變型態、（3）在行為—流感網絡傳輸下，NM-II 模式可作爲評估有效之 MI_{max}、及（4）在行為—流感系統中，行為改變模式可反應控制策略之負回饋效果。

由本研究結果可知，運用量化訊息理論為基礎之行為—流感傳輸網絡模式，以了解民眾對於新興傳染疾病之反應。在流感傳輸網絡下，亦期望所構建之模式可提供風險評估者於制定控制措施具前瞻性之觀點及預測方式。

關鍵字：訊息理論；疾病族群動態；風險感知；人類行為；流感；網絡

ABSTRACT

The global burden of contagious disease is significantly associated with human behavior. Recently, it seems to be generally recognized that risk perception has been played a key role in changing human behavior for preventing disease and mitigating epidemic. Therefore, it is important to be able to quantify the risk perception and behavior change impact on the infectious disease transmission network.

The purposes of this study were (*i*) to conduct the survey to evaluate quantitatively age-specific risk perception and behavior changes during the seasonal influenza, (*ii*) to use behavior-influenza models for evaluating the interaction between the spread of risk perception and influenza transmissibility in disease population dynamics, (*iii*)to incorporate information theory into the behavior-influenza models and the network behavior-influenza models to predict amount of risk perception spread in the influenza transmission networks, (*iv*) to use a probabilistic infection risk model to predict the infection risk of influenza, and (*v*) to use behavior change models to assess the impacts of health behavior change on the control effectiveness.

This study conducted risk perception and health behavior surveys to provide age-and region-specific risk perception with health behavior responses information before (survey I) and during (survey I) seasonal influenza, respectively. Estimated risk perception spread rate (α) was incorporated into the proposed behavior-influenza transmission network model. The behavior-influenza transmission network model was developed by linking the behavior-influenza models and the network behavior-influenza models to elucidate the impacts of risk perception and behavior change, whereas the model without information bottleneck (IB) (NM-I model) and the model with IB (NM-II model) were considered as the network behavior-influenza models. The probabilistic risk model was further used to assess the infection risk

effect of risk perception with health behavior change. The perception-based transmission model was incorporated into the health behavior change model for the age-specific health behavior change assessment. The negative feedback control model combining with human influenza experimental data was used to assess efficacies of vaccination and antiviral drug.

In the present study, the results from survey analyses showed that (*i*) participants perceived the highest self-risk level by themselves than that based on the sources of government and reference information in surveys I and II, (*ii*) youngers aged 10 – 19 and 25 – 34yrs induced high percentage of perception scores than that aged 20 – 24 yr, and (*iii*) aged 10 – 19 and $\geq$ 45 yrs had health behavior change of personal hygiene (HB_{HP}), medication (HB_{Med}), and social distancing (HB_{SD}).

The simulation results from behavior-influenza transmission network modeling showed that (*i*) estimated α value in survey I was lower than in survey II, (*ii*) amount of risk perception information spread was increased with the effective information from contact numbers of individuals in both network behavior-influenza models, and (*iii*) maximum mutual risk perception information (MI_{max}) estimates based on the NM-I model were lower than in NM-II model.

The results from behavior change modeling indicated that (*i*) HB_{HP} and HB_{Med} behavior changes induced lower infection risk probability, (*ii*) highest MI_{max} estimates were 3.1 bits for seasonal influenza A/H1N1 with antiviral drug, 2.9 bits for A/H3N2 without any control measures, and 3.2 bits for type B with vaccination, and (*iii*) highest maximum mutual risk perception information change ratio occurred significantly in antiviral drug control behavior.

The conclusions of this study were (*i*) participants perceived the highest level of self-risk probability by themselves than that based on the sources of government and

reference information, (*ii*) youngers had significantly health behavior change patterns, (*iii*) the NM-II model can effectively represent as a tool to assess MI_{max}, and (*iv*) the behavior change model could reflect the negative feedback efficacies of control measures in a behavior-influenza transmission system.

This study could quantitatively provide an information theory-based behavior-influenza transmission network model for understanding laypeople in response to emerging infectious diseases. This stud hopes that the constructed models could provide the perspective insights and serve as a predictive way to help risk assessors in designing the control measures on influenza transmission network.

Keywords: Information theory; Disease population dynamics; Risk perception; Human behavior; Influenza; Network