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Food safety knowledge, attitudes, and eating behavior under the global coronavirus pandemic

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The objective of this lab protocol was to evaluate the relationships among food safety knowledge, attitude and eating behavior of consumers during lockdowns in the advent of the COVID-19 pandemic. A total of 157 respondents completed the online survey using a structured questionnaire worldwide. Overall, the respondents exhibited good attitude and good knowledge towards public health including food safety especially on the importance of social distancing, mask wearing, well-balanced diet, physical exercise and personal hygiene, such as hand washing during the pandemic lockdowns. A Structural Equation Modeling (SEM) was established to test the relationships among food safety knowledge, attitude and behavior under the pandemic conditions. Results showed that attitude towards food safety under the coronavirus pandemic and lockdowns positively affected the eating behavior of the respondents, which exhibited a high β (0.686) among the variables tested ($p<0.05$). Food safety knowledge was apparently not affected by the food safety behavior of the respondents.

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Food safety knowledge, attitudes, and eating behavior under the global coronavirus pandemic

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Metadata
Backgroud of socio-demographic characteristics

Nation @1、Age @2、Gender @3、Females @3、Men @3、Childrenunder18years @4、EmploymentStatus @5、HighestLevelofEducation
Iran 2 1 1 1 0 5 6
New Zealand 2 1 1 0 0 5 6
New Zealand 3 1 1 1 0 5 6
Iran 1 2 1 1 0 5 3
UK 3 1 1 0 0 2 5
Iran 4 1 1 1 0 6 5
New Zealand 2 1 1 1 1 5 6
New Zealand 2 1 1 0 0 3 6
Mongolia 2 2 0 1 0 5 5
South Africa 4 2 1 1 1 1 7
Mongolia 2 2 1 1 1 1 2
China 2 2 1 0 1 1 6
China 3 1 1 1 1 1 6
South Africa 3 2 1 1 0 1 7
China 2 2 1 1 0 5 6
South Africa 4 2 1 1 1 1 7
Lesotho 2 1 1 1 1 3 7
South Africa 1 1 1 1 1 5 5
UK 4 1 1 0 0 2 6
China 2 1 1 0 0 5 6
USA 2 2 0 1 0 5 7
South Africa 3 2 0 1 0 5 7
South Africa 2 1 1 0 0 5 7

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South Africa 1 2 1 1 1 5 3
China 5 1 1 0 0 6 6
South Africa 2 1 1 0 0 1 6
New Zealand 2 1 1 1 0 1 6
New Zealand 3 1 1 1 1 2 6
New Zealand 1 1 1 0 0 2 5
New Zealand 1 2 0 1 0 5 6
Japan 4 2 0 1 0 1 7
New Zealand 2 2 1 1 0 1 6
New Zealand 1 1 1 1 0 5 5
New Zealand 1 1 1 1 0 1 5
New Zealand 1 1 1 1 0 5 6
China 2 2 1 1 0 5 6
South Africa 1 2 0 1 0 5 6
New Zealand 2 1 1 1 0 1 6
Mongolia 2 1 1 1 0 5 5
New Zealand 2 1 1 1 0 3 5
New Zealand 1 1 1 1 1 5 3
New Zealand 2 1 1 1 0 1 5
New Zealand 2 1 1 1 0 3 5
China 4 1 0 1 0 6 5
China 2 2 0 1 0 1 6
China 4 1 0 1 0 6 5
USA 6 2 1 1 0 1 7
Canada 5 1 1 1 0 2 5
Canada 5 1 1 0 0 1 5
UK 2 2 1 1 0 1 7
South Africa 3 1 1 0 0 1 7
USA 6 2 0 1 0 1 7
China 5 1 1 1 0 6 5
New Zealand 5 1 1 0 0 1 5
New Zealand 6 2 1 1 0 6 5
New Zealand 5 2 1 1 1 2 5
New Zealand 1 1 1 1 0 1 5
New Zealand 5 1 1 1 0 1 7
New Zealand 2 1 1 1 0 1 6
Australia 5 1 1 1 0 1 5
USA 4 2 1 1 1 1 6
USA 3 2 0 1 0 1 7
China 3 2 1 1 1 1 5
China 3 1 1 1 1 1 7
Canada 2 2 1 1 0 1 6
Pakistan 3 2 1 1 1 1 5
Netherlands 1 1 1 0 0 5 3
China 1 1 1 1 0 5 5
China 1 1 1 1 1 5 5
China 1 2 1 1 1 5 5

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China 1 1 1 1 1 5 6
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China 2 1 1 1 0 1 5
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China 3 1 1 0 0 1 6
China 2 1 1 1 1 1 6
China 2 1 1 1 1 1 5
China 3 1 1 0 0 1 6
China 4 1 1 0 0 1 5
New Zealand 3 1 1 1 1 1 5
China 7 2 1 1 0 6 4
Kuwait 3 1 0 1 1 1 6
Canada 7 1 1 1 0 6 5

Scores of food safety knowledge

K8 K9 K10 K11 K12 K13 K14 K15
1 1 0 1 1 0 1 1
1 1 0 1 0 0 0 1

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1 1 1 1 1 0 1 1
1 1 1 1 1 0 0 1
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Scores of food safety attitude

A24 A25 A26 A29 A30 A31 A32 A33 A34 A35 A36 A37 A38 A39
0 0 0 1 1 1 1 0 0 1 1 1 1 1
1 1 0 1 1 1 1 1 1 1 1 1 1 1
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Scores of eating behavior

B16 B17 B18 B19 B20 B21 B22 B23 B27 B28
0 1 1 0 1 1 0 1 1 1
0 1 1 1 1 1 1 1 1 0
0 1 1 1 0 0 1 0 1 0
1 1 1 1 1 1 1 1 1 1
1 0 1 1 0 1 0 0 1 1

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Competing interests
The authors declare that they have no competing interests.
Data availability
Metadata are available in this lab protocol.
Associated content
Manuscript Number PONE-D-21-16504.
Abstract
The objective of this study was to evaluate the relationships among food safety knowledge, attitude and eating behavior of consumers during lockdowns in the advent of the COVID-19 pandemic. A total of 157 respondents completed the online survey using a structured questionnaire worldwide. Overall, the respondents exhibited good attitude and good knowledge towards public health including food safety especially on the importance of social distancing, mask wearing, well-balanced diet, physical exercise and personal hygiene, such as hand washing during the pandemic lockdowns. A Structural Equation Modeling (SEM) was established to test the relationships among food safety knowledge, attitude and behavior under the pandemic conditions. Results showed that attitude towards food safety under the coronavirus pandemic and lockdowns positively affected the eating behavior of the respondents, which exhibited a high β (0.686) among the variables tested ($p<0.05$). Food safety knowledge was apparently not affected by the food safety behavior of the respondents.

1. Introduction

The COVID-19 pandemic that emerged in 2019 has imposed huge consequences on public health and economic losses, which are still affecting many aspects of our daily life throughout the world. The objective of the present study was to explore the relationships among food safety knowledge, attitude and eating behavior under the coronavirus pandemic and related lockdowns. In the present study, alternative hypotheses were formulated based on the relationships suggested by Schwartz [ ]:

H1: Food safety knowledge directly affects the healthy eating behavior under the coronavirus pandemic.
H2: Food safety attitude directly affects the healthy eating behavior under the coronavirus pandemic.
H3: There is a statistically significant relationship between food safety knowledge and attitude under the coronavirus pandemic.

COVID-19 has been the top food safety issue [ ], and there were many studies conducted by multiple research groups during the COVID-19 Pandemic, focusing on preventative measures, perception of risk, trust of food safety information, consumer willingness to pay (WTP), and etc [, ,]. Also, there are several assessments of knowledge, attitude, and practices of residents and healthcare workers from China, Malaysia, Pakistan, Uganda, and etc [, , , ,]. Those above literatures had a number of descriptive statistical analyses of knowledge, attitude and behavior, except the relationships among them. On the other hand, based on the cognitive-affective-behavior theory in the area of social psychology, there were numbers of studies on the relationships among knowledge, attitude and behavior after Schwartz [, , ,].Thus, identifying the impacts of the COVID-19 pandemic on consumers' food safety knowledge, attitude and eating behavior under lockdown or restricted movements may be necessary to carry out an effective inactivation strategy and generate data for future planning to combat similar pandemics.

Though the findings of this study will help the policymakers to pay more attention to the public's attitude toward food safety, some limitations of this study should be considered in interpreting the results. Firstly, there was no confirmation that they were taken correctly during the completion of questionnaire, since the data collected fully relied on self-reporting from respondents. Secondly, this study was conducted among the respondents who were invited by email, Facebook, Wechat and other social media software. Limited to the researcher's background, although it took 8 months to collect data, most of the respondents were students or staff with higher education.

2. Materials and methods

This study was conducted online during the global coronavirus pandemic. The respondents were randomly selected through emails, social media platforms, personal contacts, as well as professional websites, and the response rate obtained in this study was 100%. Questionnaire was constructed and divided into 4 parts consisting of socio-demographic characteristics, food safety knowledge, attitude and eating behavior. Part I was used to collect data on gender, age, composition of household, employment status, level of education, and location of the participants. Part II on food safety knowledge included 9 questions that tested the knowledge of COVID-19 (5 items), and food safety (4 items) of the participants. Parts III and IV evaluated the food safety attitude using 14 questions on health issues under coronavirus pandemic, and 10 questions on changes in eating behavior of the participants, respectively. Each question consisted of 2 optional answers ("yes", or "no"), which were intended to prevent the participants to select the correct answer by guessing. Each correct response or healthy habit was allocated 1 point and an incorrect response 0 point.

Part I Demographic characteristics
Gender
Male
Female
Age(years)

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18-24
25-34
35-44
45-54
55-64
65-74
75-
Composition of household
Children under 18 years
No child
Employment Status
Employed, working full-time
Employed, working part-time
Not employed, looking for work
Not employed, not looking for work
Student
Retired
Highest Level of Education
Primary School or equivalent
Intermediate Diploma/Certificate or Equivalent
High School Diploma/Certificate or equivalent
Technical skills qualification or Equivalent
Bachelor's Degree/Equivalent
Master's Degree/Equivalent
Doctorates Degree (PhD)/Equivalent
Medical/Health Professional
Other qualifications

Part II Knowledge of Coronavirus COVID-19 & food safety
K7. The coronavirus COVID-19 can be easily transmitted between among humans.
K8. A person contaminated by coronavirus COVID-19 must undergo self-isolation, even without showing any symptoms.
K9. The vaccination against seasonal influenza is not effective against coronavirus COVID-19.
K10.The coronavirus COVID-19 on hands can be eliminated by hand-washing using ordinary soap.
K11. Coronavirus on food can be killed during cooking food.
K12. Coronavirus on surfaces can be killed by disinfectants.
K13. The coronavirus COVID-19 cannot be easily transmitted through contaminated food.
K14. Even when it is contaminated, food is not a health risk if it is thoroughly cooked.
K15. Humans can catch coronavirus by touching contaminated surfaces of food packaging box.

Part III Attitude and preparedness for COVID-19
A24. I ate a balanced diet.
A25. I ate sufficient amounts of fresh fruit and vegetables.
A26. I ate sufficient amounts of fresh meat and fish.
A29. Wash hands often.
A30. Avoid eating meat or fish not thoroughly cooked.
A31. Avoid eating fruit or vegetable not thoroughly washed.

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A32. Exercise regularly.
A33. Maintain a well-balanced diet.
A34. Keep air circulating in rooms.
A35. Avoid shaking hands with others and touching packages with bare (unprotected) hands.
A36. Avoid going to crowded public areas.
A37. Wear masks in public areas.
A38. Social distancing always be observed.
A39. Working from home is the new normal.

Part IV Eating habits under COVID-19
B16. My eating habits did not change under the coronavirus covid-19 pandemic.
B17. I maintained the same eating habits by purchasing more takeaways or fast foods.
B18. I maintained the same eating habits by cooking more at home.
B19. I somehow ate more food under coronavirus covid-19.
B20. I somehow ate less food under coronavirus covid-19
B21. I somehow ate the same amount of food under coronavirus covid-19.
B22. I somehow ate food more frequently.
B23. I somehow ate food less frequently.
B27. I ate more canned foods.
B28. I ate foods with longer shelf life.

3. Results and discussion
Data collection was performed online using the survey platform of www.WJX.cn. The online questionnaire was available in two versions, in English and Chinese.The call for participation was made on social media. After 8 months, 157 sample data from 14 countries were collected, that is considered enough sample size for conducting SEM [, , ,].

Data were analyzed by IBM SPSS (The Statistical Package for Social Sciences) for descriptive analysis, normality test, reliability analysis, Pearson's correlation coefficient analysis and Exploratory Factor Analysis (EFA). Confirmatory Factor Analysis (CFA) and structural equation modeling were conducted by MPLUS 8.3 with confidence level of 95%.

A total of 157 questionnaires were completed in 5 continents with the majority of the respondents being female (65.6%) (Table 1). The age group of the respondents peaked at 25-34 years, which accounted for 42.7%. Data showed that most respondents actually came from families without children (59.9%) and 40.1% had at least 1 child under 18 years. More than half of the respondents had full-time work (52.9%), and a third were students (33.1%). In terms of educational background, 95.5% of respondents had attained college education.

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Table 1 Demographic characteristics of respondents (n = 157)

Variable	Items	Frequency	Percentage
Country/Region	Australia	1	0.006
	Canada	4	0.025
	China	99	0.631
	Iran	3	0.019
	Japan	1	0.006
	Kuwait	1	0.006
	Lesotho	1	0.006
	Mongolia	3	0.019
	Netherlands	1	0.006
	New Zealand	24	0.153
	Pakistan	1	0.006
	South Africa	10	0.064
	UK	3	0.019
	USA	5	0.032
Gender	Male	54	0.344
	Female	103	0.656
Age(years)	18-24	44	0.280
	25-34	67	0.427
	35-44	23	0.146
	45-54	10	0.064
	55-64	8	0.051
	65-74	3	0.019
	75-	2	0.013
Composition of household	Children under 18 years	63	0.401
	No child	94	0.599
Employment Status	Employed, working full-time	83	0.529
	Employed, working part-time	8	0.051
	Not employed, looking for work	5	0.032
	Not employed, not looking for work	1	0.006
	Student	52	0.331
	Retired	8	0.051
Highest Level of Education	Primary School or equivalent	0	0.000
	Intermediate Diploma/Certificate or Equivalent	1	0.006
	High School Diploma/Certificate or equivalent	4	0.025
	Technical skills qualification or Equivalent	2	0.013
	Bachelor's Degree/Equivalent	63	0.401
	Master's Degree/Equivalent	72	0.459
	Doctorates Degree (PhD)/Equivalent	15	0.096
	Medical/Health Professional	0	0.000
	Other qualifications	0	0.000

Table 2 shows that, the mean score of food safety knowledge was 6.64 (full score was 9), implying the food safety knowledge of the respondents on COVID-19 was rather high. Results also suggest that there was excessive worry on the health risk caused by contaminated food. The lowest score among food safety knowledge items was item K13, indicating that many respondents had great concern to the transmissibility of the coronavirus COVID-19 through contaminated food. Compared with disinfectants, the function of ordinary soap seemed to have been ignored by many respondents. Based on the mean scores obtained for food safety attitude (full score was 14), the respondents seemed to demonstrate poor attitude on the adequacy of the amounts of fresh meat and fish (A26) consumed and regular exercises conducted (A32). Results showed that, half of the respondents changed their eating habits and tended to consume more food under lockdowns. Based on the results of data collected, over 90% of the respondents maintained their eating habits by cooking at home. All items used in accessing healthy eating behavior showed that respondents had reasonably good behavior in eating practices with all the mean value scores higher than 70% of the full score.

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Table 2 Mean scores of items in food safety knowledge, attitude, and behavior.

Construct	Item	Mean
Food safety knowledge	K7. The coronavirus COVID-19 can be easily transmitted between among humans.	0.994
	K8. A person contaminated by coronavirus COVID-19 must undergo self-isolation, even without showing any symptoms.	0.994
	K9. The vaccination against seasonal influenza is not effective against coronavirus COVID-19.	0.892
	K10.The coronavirus COVID-19 on hands can be eliminated by hand-washing using ordinary soap.	0.529
	K11. Coronavirus on food can be killed during cooking food.	0.771
	K12. Coronavirus on surfaces can be killed by disinfectants.	0.815
	K13. The coronavirus COVID-19 cannot be easily transmitted through contaminated food.	0.280
	K14. Even when it is contaminated, food is not a health risk if it is thoroughly cooked.	0.490
	K15. Humans can catch coronavirus by touching contaminated surfaces of food packaging box.	0.879
Food safety attitude	A24. I ate a balanced diet.	0.809
	A25. I ate sufficient amounts of fresh fruit and vegetables.	0.783
	A26. I ate sufficient amounts of fresh meat and fish.	0.586
	A29. Wash hands often.	0.981
	A30. Avoid eating meat or fish not thoroughly cooked.	0.904
	A31. Avoid eating fruit or vegetable not thoroughly washed.	0.917
	A32. Exercise regularly.	0.650
	A33. Maintain a well-balanced diet.	0.828
	A34. Keep air circulating in rooms.	0.892
	A35. Avoid shaking hands with others and touching packages with bare (unprotected) hands.	0.930
	A36. Avoid going to crowded public areas.	0.975
	A37. Wear masks in public areas.	0.930
	A38. Social distancing always be observed.	0.975
	A39. Working from home is the new normal.	0.911
Healthy eating behavior	B16. My eating habits did not change under the coronavirus covid-19 pandemic.	0.522
	B17. I maintained the same eating habits by purchasing more takeaways or fast foods.	0.866
	B18. I maintained the same eating habits by cooking more at home.	0.904
	B19. I somehow ate more food under coronavirus covid-19.	0.554
	B20. I somehow ate less food under coronavirus covid-19	0.815
	B21. I somehow ate the same amount of food under coronavirus covid-19.	0.599
	B22. I somehow ate food more frequently.	0.605
	B23. I somehow ate food less frequently.	0.828
	B27. I ate more canned foods.	0.854
	B28. I ate foods with longer shelf life.	0.611

The results shown in Figure 1 supported H2 (the healthy eating behavior, directly affected by food safety attitude) by revealing a significant (β=0.686, $p<0.05$) positive relation between food safety attitude and healthy eating behavior. In fact, food safety attitude was the most important factor claimed by the respondents to influence their eating behavior under the COVID-19 and lockdown as shown by the high standard of β (β=0.686) among the variables (at $p< 0.05$). Previous studies have confirmed that a positive attitude can lead to food safety behavior [ ],[ ], [ ]. Hence, positive attitude under COVID-19 and lockdown could be only achieved when one believed that balanced diet and regular exercise could reduce the long-lasting adverse health outcomes, such as anxiety, frustration, panic attacks, loss

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or sudden increase of appetite, insomnia, depression, mood swings, delusions, fear and suicidal tendencies [ ]. As illustrated in Figure 1, food safety knowledge and attitude of the respondents had very low correlations. The findings obtained in the present study were similar to the results of a study on relationships reported by Schwardtz (1975) where knowledge and attitude independently influenced behavior. However, most studies showed that there was either a positive or negative correlation of relationship between food safety knowledge and attitude [ ].

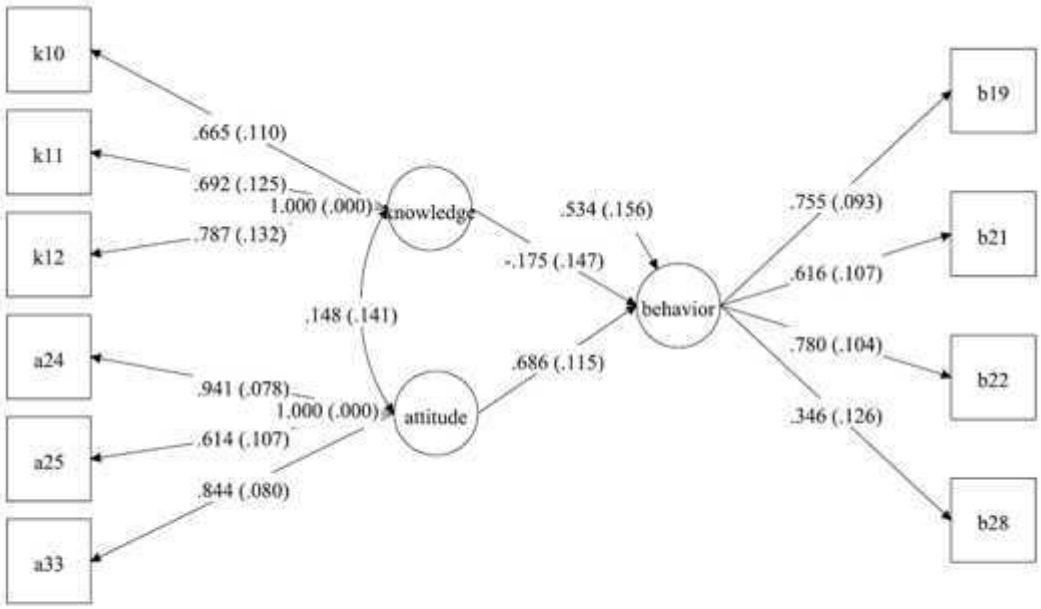

Fig. 1 The model of food safety knowledge, attitude and eating behaviors

Ethics declarations

Collection of data using the online survey was covered by a Low Risk Ethics Application (Notification Number 4000022746) granted by Massey University Ethics Committee.

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