### SUPPLEMENTARY MATERIALS

#### Table S1. Search terms applied on PubMed and Web of Science for L. monocytogenes risk assessment models on leafy greens dating back from 2007. See exact search terms below.

|  |  |  |
| --- | --- | --- |
| **Criteria #** | | **Search Terms** |
| 1 | Title or Abstract contained any of the following:   * Listeria spp.; L. monocytogenes; Listeria monocytogenes; Listeria; L.mono; L. spp | |
| 2 | Title or Abstract contained any of the following:   * Leafy Green; Romaine; Lettuce; Spinach; Leafy Vegetable | |
| 3 | **Title or Abstract contained either of the following:**   * **Risk Assessment; Model** | |
| **Final Search** | **Criteria #1, #2, and #3** and publication year in the range any of the following:   * 2007 to 2023 | |

#### Table S2. Search terms applied on PubMed and Web of Science for STEC risk assessment models on leafy greens dating back from 2017. See exact search terms below.

|  |  |
| --- | --- |
| **Criteria #** | **Search Terms** |
| 1 | Title or Abstract contained any of the following:   * E.coli; STEC; shiga; Escherichia coli |
| 2 | Title or Abstract contained any of the following:   * Leafy Green; Romaine; Lettuce; Spinach; Leafy Vegetable |
| 3 | **Title or Abstract contained either of the following:**   * **Risk Assessment; Model** |
| **Final Search** | **Criteria #1, #2, and #3** and publication year in the range any of the following:   * 2017 to 2023 |

Exact searches for Table S1 and S2, respectively.

|  |  |
| --- | --- |
| **Criteria** | **Search String** |
| 1 | (((((((((((TI=(Listeria spp.)) OR TI=(L. monocytogenes)) OR TI=(Listeria monocytogenes)) OR TI=(Listeria)) OR TI=(L.mono)) OR TI=(L. spp)) OR AB=(Listeria spp.)) OR AB=(L. monocytogenes)) OR AB=(Listeria monocytogenes)) OR AB=(Listeria)) OR AB=(L.mono)) OR AB=(L. spp) |
| 2 | (((((((((TI=(leafy green)) OR TI=(romaine)) OR TI=(lettuce)) OR TI=(spinach)) OR TI=(leafy vegetable)) OR AB= (leafy green)) OR AB=(romaine)) OR AB=(lettuce)) OR AB=(spinach)) OR AB=(leafy vegetable) |
| 3 | **(((TI=(risk assessment)) OR TI=(model)) OR AB=(risk assessment)) OR AB=(model)** |
| 4 | **#1 AND #2 AND #3** and **2023** or **2022** or **2021** or **2020** or **2019** or **2018** or **2017** or **2016** or **2015** or **2014** or **2013** or **2012** or **2011** or **2010** or **2009** or **2008** or **2007** (Publication Years) |

|  |  |
| --- | --- |
| Criteria | Search String |
| 1 | (((((((TI=(E.coli)) OR TI=(STEC)) OR TI=(shiga)) OR TI=(Escherichia coli)) OR AB=(E.coli)) OR AB =(STEC)) OR AB=(shiga)) OR AB=(Escherichia coli) |
| 2 | (((((((((TI=(leafy green)) OR TI=(romaine)) OR TI=(lettuce)) OR TI=(spinach)) OR TI=(leafy vegetable)) OR AB= (leafy green)) OR AB=(romaine)) OR AB=(lettuce)) OR AB=(spinach)) OR AB=(leafy vegetable) |
| 3 | **(((TI=(risk assessment)) OR TI=(model)) OR AB= (risk assessment)) OR AB=(model)** |
| 4 | **#1 AND #2 AND #3** and **2023** or **2022** or **2021** or **2020** or **2019** or **2018** or **2017** (Publication Years) |

**Table S3:** Statements used to describe where data sources originated from in Tables 3-6 in the manuscript and Tables S4- S7

|  |  |
| --- | --- |
| Statement | Definition |
| Author-generated | The authors of the **reviewed model** use a value or distribution from their experimental data |
| Value taken from \_\_ | The authors of the **reviewed model** use a numerical value (i.e., point estimate) from a data source |
| Distribution taken from \_\_ | The authors of the **reviewed model** use a distribution from data source(s) and do not modify the distribution |
| Distribution taken from \_\_\* | The authors of the **reviewed model** use a distribution from source(s) not publicly accessible (e.g., industry data) |
| Distribution fitted from author-generated data | The authors of the **reviewed model** fit a distribution using data gathered from their own experiment(s) |
| Distribution fitted from data from \_\_ | The authors of the **reviewed model** fit a distribution using data from single or multiple data sources |
| Distribution fitted from data from \_\_\* | The authors of the **reviewed model** fit a distribution using data from source(s) not publicly accessible |
| Distribution fitted from values calculated in this **model** | The authors of the **reviewed model** fit a distribution using values calculated in a preceding step in the model |
| Calculated from author-generated data | The authors of the **reviewed model** perform a mathematical operation using parameter(s) based on their experimental data |
| Calculated from \_\_ | The authors of the **reviewed model** perform a mathematical operation to obtain the parameter |
| Calculated from value(s) or distribution(s) defined in this **model** | The authors of the **reviewed model** performed a mathematical operation using parameters already defined in the model |
| Calculated from value(s) or distribution(s) defined in this **model** using an equation from \_\_ | The authors of the **reviewed model** performed a mathematical operation using parameters already defined in the model, the equation which came from an external source |

#### Table S4. Microbial growth model and dose-response parameter values found in the reviewed models for STEC.

| **Model Type**  *Parameter Category*  Parameter or Equation (symbol) | Value | Unit | Reviewed Model(s) Abbreviation |
| --- | --- | --- | --- |
| **1. Microbial Growth** | | | |
| *1.1 Primary Growth* | | | |
| STEC concentration at time *t* | Growth when Temperature > 5 ℃:  Growth when Temperature < 5 ℃:  where k = Lognormal (0.013,0.001, Shift (0.001))/2.303 Log10 (CFU/g/h) | Log10 (CFU/g) | PG17, BZ21 |
|  | Log10 (CFU/g) | MK18 |
| given | Log10 (CFU/g) | PG22 |
| )  given | ln (CFU/g) | MD22 |
| given where α = 0.056 | ln (CFU/g) | MK22 |
| *1.2 Secondary Growth* | | | |
| Growth rate (μ) **1** |  | or Log10  (CFU/g/h) | PG17, CM18, BZ21, MK22, PG22, MD22, BV23 |
| STEC growth model parameter (Tmin) **2, 3** | 1.2  where 1.335 - (5.766 × b) | ℃ | PG17, BZ21, BV23 |
| 2.628 | ℃ | CM18 |
| -4.012 | ℃ | MD22 |
| 4.54 | ℃ | MK22, PG22 |
| Regression coefficient (b) | 0.023 | unitless | PG17, BZ21, BV23 |
| 0.0616 | unitless | CM18 |
| 0.0169 | unitless | MD22 |
| 0.033 | unitless | MK22, PG22 |
| Maximum population density (Xmax) **4** | 7 | Log10 (CFU) | PG17, CM18, PG22 |
|  | ln (CFU/g) | MD22 |
|  | Log10 (CFU) | MK22, BV23 |
| Lag time (λ) |  | h | MD22 |
| **2. Dose-Response Model** | | | |
| Serving size (SS) | 85 | g | PG17 |
| Empirical distribution, μ = 44.8, σ = 51.7, 95% probability range: [4, 182.2] | g | MK22 |
| Empirical distribution,  μ = 44.8 | g/day | PG22 |
| 50 | g | BV23 |
| Per capita consumption of lettuce (Acons) | Triangular (0.123404, 0.123404, 0.170155) | g/kg/day | BZ21 |
| 132.86 | kg/year | BV23 |
| Probability of illness (Pillness) **5** |  | unitless | MK22, BZ21, PG17 |
|  | unitless | PG22 |
| where R = | unitless | BV23 |
| Dose response parameter (α) | 0.267 | unitless | PG17, BZ21 |
| 0.0571 | unitless | MK22, PG22 |
| Dose response parameter (β) | 229.2928 | unitless | PG17, BZ21 |
| 2.2183 | unitless | MK22, PG22 |

**1** PG17 and BZ21 transformed the growth rate from natural log units to Log10 units by squaring µ and dividing by 2.303.

**2** A negative value for Tmin in the reviewed model MD22 was inferred, as Ratkowsky model is presented in the main text of the manuscript as *T + Tmin.*

**3** The theoretical minimum growth temperature for STEC used for secondary growth in PG17 and BZ21 **is different than the temperature threshold used to determine whether the growth or die-off is calculated at a given time, which is 5℃ in these reviewed models.** To see where the temperature threshold is used t, see our Supplementary Materials STEC table, parameters: QP-R, QR, QR-H, QH.

**4** The reader is encouraged to carefully review the methods for calculating Xmax employed by MD22 and MK22 before use in future risk assessment.

**5** PG17 and BZ21 multiplied this equation by the prevalence of contaminated finished product.

#### Table S5. Microbial growth model and dose-response parameter data sources found in the reviewed models for STEC.

| **Model Type**  *Parameter Category*  Parameter or Equation (symbol) | Parameter source | Reviewed Model(s) Abbreviation |
| --- | --- | --- |
| **1. Microbial Growth Model** | | |
| *1.1 Primary Growth Models* | | |
| STEC concentration at time *t* | Calculated from values defined in this study and values from McKellar & Delaquis (2011) using equation taken from Buchanan et al. (1997) | PG17, BZ21 |
| Calculated from values and equations taken from Pérez Rodríguez et al. (2011), using the Weibull model | MK18 |
| Calculated from values defined in this study using equations taken from Baranyi & Roberts (1994) | PG22 |
| Calculated from values defined in this study using equations taken from Velugoti et al. (2011), which originated from Baranyi et al. (1995) and Baranyi & Roberts (1994) | MD22 |
| Calculated from values defined in this study using equations taken from Koseki & Isobe (2005), which originated from Baranyi & Roberts (1994) | MK22 |
| *1.2 Secondary Growth Models* | | |
| Growth rate (μ) | Calculated from values defined in this study using equation taken from Ratkowsky et al. (1982) | PG17, CM18, BZ21, MK22, PG22, BV23 |
| Calculated from values defined in this study using equation taken from Velugoti et al. (2011), which originated from Ratkowsky et al. (1982) | MD22 |
| STEC growth model parameter (Tmin) | Value taken from McKellar & Delaquis (2011) | PG17, BZ21, BV23 |
| Value taken from Danyluk & Schaffner (2011) | CM18 |
| Value taken from Ding et al. (2009) | MD22 |
| Value taken from Koseki & Isobe (2005) | MK22, PG22 |
| Regression coefficient (b) | Value taken from McKellar & Delaquis (2011) | PG17, BZ21 |
| Value taken from Danyluk & Schaffner (2011) | CM18 |
| Value taken from Ding et al. (2009) | MD22 |
| Value taken from Koseki & Isobe (2005) | MK22, PG22 |
| Maximum population density (Xmax) | Assumed value | PG17, CM18, PG22 |
| Calculated from values from Ding et al. (2009) using equations taken from Velugoti et al. (2011), which originated from Baranyi et al. (1995) | MD22 |
| Calculated from values taken from Koseki & Isobe (2005) | MK22, BV23 |
| Lag time (λ) | Calculated from values from Ding et al. (2009) using equations taken from Velugoti et al. (2011), which originated from Baranyi et al. (1995) | MD22 |
| **2. Dose-Response Model** | | |
| Serving size (SS) | Value taken from FDA 2015**\*** | PG17 |
| Distribution fitted from data from CDC 2013**\*** | MK22 |
| Distribution fitted from data from CDC 2013**\*** | PG22 |
| Value taken from Sant'Ana et al. (2014), Söderqvist et al. (2017), and Söderqvist et al. (2019) |  |
| Per capita consumption of lettuce (Acons) | Distribution fitted from data from Hamilton et al. (2006) | BZ21 |
| Value taken from Freshfel (2022) | BV23 |
| Probability of illness (Pillness) | Calculated from values and an equation from Strachan et al. (2005) | MK22 |
| Calculated from values from Cassin et al. (1998) using an equation from Danyluk & Schaffner (2011) | BZ21, PG17 |
| Calculated from values from Strachan et al. (2005) and an equation from Haas (2002) | PG22 |
| Calculated from values and an equation from Söderqvist et al. (2017), and Söderqvist et al. (2019), which originated from Strachan et al. (2005) | BV23 |
| Dose response parameter (α) | Value taken from Cassin et al. (1998) | PG17, BZ21 |
| Value taken from Strachan et al. (2005) | MK22, PG22 |
| Dose response parameter (β) | Value taken from Cassin et al. (1998) | PG17, BZ21 |
| Value taken from Strachan et al. (2005) | MK22, PG22 |

**\*** Data were not publicly accessible

#### Table S6. Microbial growth model and dose-response parameter values found in the reviewed models for L. monocytogenes.

| **Model Type**  *Parameter Category*  Parameter or Equation (symbol) | Value | Unit | Reviewed Model(s) Abbreviation |
| --- | --- | --- | --- |
| **1. Microbial Growth** | | | |
| *1.1 Primary Growth* | | | |
| *L. monocytogenes* concentration at time t |  | CFU/g | FZ10, RB10 |
|  | Log10(CFU/g) | CO10 |
| given | Log10(CFU/g) | DG13 |
| )  given | ln CFU/g | OM17 |
| *1.2 Secondary Growth* | | | |
| Maximum specific growth rate () |  | 1/h | FZ10, TP10, RB10, CO10, DG13, SA14, OM17 |
| Minimum growth temperature (Tmin) | -4.26 | °C | FZ10, TP10, RB10, CO10, DG13, OM17 |
| 1.6 | °C | SA14 |
| Regression coefficient (b) | 0.016 | √h/°C | FZ10, TP10, RB10, CO10, DG13 |
| 0.0144 | √Log10 CFU/day/°C | SA14 |
| 0.026 | √h/°C | OM17 |
| Maximum population density (Xmax) | 0.037Tmin + 12.434 | ln (CFU/g) | FZ10, TP10, CO10 |
| 105 | CFU/g | RB10 |
|  | ln (CFU/g) | OM17 |
| **2. Dose-Response** | | | |
| Serving size (SS) | Log-logistic (6.51, 81.71, 2.47) | g | FZ10, TP10 |
| Pert (25,50,75) | g | SA14 |
| Cumulative (25; 200;{28;55;123}  ;{0.5;0.75;0.95}) | g | CO10 |
| Cumulative (0,220,{12,20,36, 60,80,121}, {0.25,0.5,0.75,0.9,0.95,0.99}) | g | OM17 |
| Probability of infection from a single cell (r) | 1.91 × 10−10 | Unitless | FZ10, TP10 |
| Pert (1.11 × 10−15,4.47 × 10−11,  1.36 × 10−9) | Unitless | SA14 |
| **Low-risk:** 2.23 × 10−13  **High-risk:** 8.61× 10−12 | Unitless | DG13**2** |
| Pert (0.000000000158,0.000000000191,  0.000000000224) | Unitless | OM17 |
| Probability of exposure (Pexp) | Beta (1 + 1, 2,641 − 1 + 1) | Unitless | FZ10, TP10 |
| Discrete ({1\2\12\30},  {0.43\0.23\0.27\0.07}) | Number of servings/month | SA14 |
| Probability of infection per consumption of one serving per dose (P(D)) | 1−e−rD | Unitless | FZ10, TP10, SA14, DG13, OM17 |
| 1−[1+(Db)/β]−α where *α =* 0.25, b = 2.14, and *β* = 1015.26 for low risk population and 1010.98 for high risk population | Unitless | CO10 |

**1** The number of days the authors considered per year in their model.

**2** The values included in the table are median r-values.

#### Table S7. Microbial growth model and dose-response parameter data sources found in the reviewed models for L. monocytogenes.

| **Model Type**  *Parameter Category*  Parameter or Equation (symbol) | Parameter Source | Reviewed Model(s) Abbreviation |
| --- | --- | --- |
| **1. Microbial Growth Model** | | |
| *1.1 Primary Growth Models* | | |
| *L. monocytogenes* concentration at time t | Calculated from using modified equation from Baranyi & Roberts (1994) | FZ10, RB10, OM17**1** |
| Calculated using equation from Buchanan et al. (1997) | CO10 |
| Calculated from using modified equation from Gibson et al. (1988)**2** | DG13 |
| *1.2 Secondary Growth Models* | | |
| Maximum specific growth rate() | Calculated using the equation from **Ratkowsky** et al. (1982) | FZ10, TP10, RB10, CO10, DG13, SA14, OM17 |
| Minimum growth temperature (Tmin) | Calculated from Koseki & Isobe (2005) | FZ10, TP10, RB10, CO10, DG13, OM17 |
| Value taken from Sant'Ana et al. (2012) | SA14 |
| Regression coefficient (b) | Calculated from Koseki & Isobe (2005) | FZ10, TP10, RB10, CO10, DG13 |
| Value taken from Sant'Ana et al. (2012) | SA14 |
|  | Value taken from Omac (2014) | OM17 |
| Maximum population density (Xmax) | Calculated using an equation from Koseki & Isobe (2005) | FZ10, TP10, CO10 |
| Calculated using values defined in this study | RB10 |
| Calculated using the equation from (Omac, 2014) | OM17 |
| **2. Dose-Response Model** | | |
| Serving size (SS) | Distribution fitted from author-generated value | FZ10, TP10 |
| Assumed value | SA14 |
| Distribution fitted from data from FDA-HHS & USDA-FSIS (2003) | CO10 |
| Distribution fitted from data from Hoelzer et al. (2012) | OM17 |
| Probability of infection from a single cell (r) | Value taken from Chen et al. (2006) | FZ10, TP10 |
| Distribution taken from Mataragas et al. (2010) | SA14 |
| Values calculated from data from FAO/WHO (2004) | DG13 |
| Distribution fitted from data from Chen et al. (2006) | OM17 |
| Probability of exposure (Pexp) | Distribution fitted from data from Pielaat et al. (2008) | FZ10, TP10 |
| Distribution fitted from data from Perez et al. (2008) | SA14 |
| Probability of infection per consumption of one serving per dose (P(D)) | Calculated using an equation from exponential dose-response model | FZ10, TP10, SA14, DG13, OM17 |
| Calculated using the model from Farber et al. (1996) | CO10 |

**1** FZ10 and TP10 removed lag phase from the Baranyi and Roberts model, so they used a different form of function from OM17.

**2**Gompertz equation was used as a primary growth model for DG13.

**For a full list of all growth model and dose-response parameters and equations, please visit our Supplementary Materials folder on GitHub and download the Excel spreadsheets** (<https://github.com/foodsafetylab/Pinto-and-Jung-2024-Lit-Review/tree/main>)

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