

Acute Gastrointestinal Illness Risks in North Carolina Community Water Systems: A Methodological Comparison

Supporting Information

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The supplemental materials contain the following information:

Tables:

1. Characteristics of community water systems in North Carolina (NC)
2. Total monthly and acute maximum contaminant level (MCL) violations, January 2006 to December 2013
3. Dose-response and morbidity data used in quantitative microbial risk assessment (QMRA)
4. QMRA model parameters
5. County estimates of emergency department (ED) visits for acute gastrointestinal illness (AGI) and total AGI cases attributable to microbial contamination in CWSs per 10,000 people (mean and 95% confidence interval)

Figures:

1. Cumulative probability distribution representing the fraction of AGI attributable to microbial contamination of drinking water in a randomly selected NC community water system
2. Empirical cumulative distribution of number of MCL violations among the 2,120 community water systems in NC during 2006-2013
3. Sensitivity of the risk estimates to changes in the input variables of the quantitative microbial risk assessment (QMRA) model
4. Monthly incidence rate of emergency department (ED) visits for acute gastrointestinal illness (AGI) per 10,000 people from January 2007 to October 2013
5. Monthly incidence rates of monthly maximum contaminant level (MCL) violations in NC community water systems from January 2006 to December 2013

Table S1. Characteristics of community water systems in North Carolina

Size Category	Description	Number of Systems	Population Served	Groundwater Systems	Surface Water Systems
Very small	Serves 25-500 people	1,510	227,341	91%	9%
Small	Serves 501-3,300	345	487,176	64%	36%
Medium	Serves 3,301-10,000	136	798,471	39%	61%
Large	Serves 10,001-100,000	117	3,061,791	28%	72%
Very large	Serves more than 100,000	12	2,941,601	8%	92%

Table S2. Total monthly and acute maximum contaminant level (MCL) violations, January 2006 to December 2013

County	Number of CWSs	Number of Water Samples	Total Monthly MCL Violations	Total Acute MCL Violations
ALAMANCE	35	8,985	28	1
ALEXANDER	8	2,938	0	0
ALLEGHANY	4	537	4	1
ANSON	7	1,970	11	1
ASHE	12	1,396	0	0
AVERY	20	2,322	2	0
BEAUFORT	11	4,227	29	0
BERTIE	8	2,048	16	0
BLADEN	11	3,115	11	0
BRUNSWICK	16	14,231	9	0
BUNCOMBE	54	13,397	16	1
BURKE	20	6,025	0	0
CABARRUS	46	10,328	25	1
CALDWELL	14	6,682	0	0
CAMDEN	2	1,119	0	0
CARTERET	35	7,489	45	1
CASWELL	7	875	3	0
CATAWBA	87	14,813	4	0
CHATHAM	23	6,189	17	1
CHEROKEE	6	1,448	2	0
CHOWAN	2	1,605	5	1
CLAY	5	561	0	0
CLEVELAND	8	5,236	3	0
COLUMBUS	19	4,322	12	1
CRAVEN	13	9,818	31	0

County	Number of CWSs	Number of Water Samples	Total Monthly MCL Violations	Total Acute MCL Violations
CUMBERLAND	36	21,454	31	3
CURRITUCK	11	2,967	5	0
DARE	8	3,363	7	0
DAVIDSON	5	10,322	20	0
DAVIE	3	4,337	8	0
DUPLIN	14	5,904	3	0
DURHAM	19	10,622	11	5
EDGECOMBE	8	2,469	23	0
FORSYTH	19	10,892	11	1
FRANKLIN	21	3,893	20	1
GASTON	160	29,872	55	0
GATES	2	1,076	3	0
GRAHAM	6	912	0	0
GRANVILLE	11	3,041	7	0
GREENE	10	2,229	10	0
GUILFORD	83	24,195	62	4
HALIFAX	11	4,655	15	0
HARNETT	7	6,408	11	0
HAYWOOD	13	5,019	9	3
HENDERSON	40	7,103	10	0
HERTFORD	8	2,276	8	1
HOKE	8	4,688	23	0
HYDE	2	764	3	0
IREDELL	58	13,378	22	1
JACKSON	41	5,477	22	1
JOHNSTON	49	13,298	40	4
JONES	3	1,253	2	0
LEE	6	3,388	7	0
LENOIR	8	6,213	13	0
LINCOLN	11	2,622	1	0
MACON	22	3,598	3	0
MADISON	5	1,026	1	0
MARTIN	10	2,046	13	0
MCDOWELL	22	2,394	4	1
MECKLENBURG	39	19,166	17	3
MITCHELL	6	1,091	1	0
MONTGOMERY	10	1,764	7	0
MOORE	27	9,882	18	2
NASH	21	6,136	19	0
NEW HANOVER	25	14,141	17	1
NORTHAMPTON	13	2,607	9	0

County	Number of CWSs	Number of Water Samples	Total Monthly MCL Violations	Total Acute MCL Violations
ONSLOW	18	3,795	29	2
ORANGE	32	10,191	26	2
PAMLICO	2	1,853	6	0
PASQUOTANK	2	3,558	0	0
PENDER	16	5,105	4	0
PERQUIMANS	3	1,350	5	0
PERSON	4	879	1	0
PITT	14	11,647	39	3
POLK	7	1,245	1	0
RANDOLPH	36	7,724	35	4
RICHMOND	4	3,767	2	0
ROBESON	10	4,435	3	1
ROCKINGHAM	33	7,332	38	0
ROWAN	42	9,771	10	1
RUTHERFORD	16	3,031	9	0
SAMPSON	16	3,544	9	0
SCOTLAND	5	1,050	0	0
STANLY	19	4,327	17	0
STOKES	8	1,758	2	0
SURRY	41	4,858	16	0
SWAIN	6	978	3	0
TRANSYLVANIA	17	2,580	9	0
TYRRELL	2	592	4	0
UNION	6	3,836	1	0
VANCE	9	2,123	3	1
WAKE	309	68,518	163	8
WARREN	14	2,313	5	0
WASHINGTON	4	1,457	7	0
WATAUGA	27	5,038	3	0
WAYNE	9	10,785	29	1
WILKES	9	4,404	1	0
WILSON	10	5,190	14	0
YADKIN	12	2,306	15	1
YANCEY	4	613	0	0

Table S3. Quantitative microbial risk assessment model parameters

Exposure Parameter	Symbol(s)	Distribution or Equation	Distribution Parameters	Data Source
Water consumption rate (L/day)	I	Lognormal	Mean: 1.129 SD: (0.67)*	Roseberry and Burmaster 1992
Exposure duration (days)	t	Lognormal	Mean: 3.95 SD: 6.77	J. Cavalier, NCDENR, e-mail communication, March 21, 2014
National AGI rate (person-month ⁻¹)	$AGI_{national}$	Uniform	Min: 0.046 Max: 0.06	Jones et al. 2007; Scallan et al. 2011a,b
Mean value of total coliform concentration in CWS i , month j (MPN-L)	$\mu TC_{i,j}$	Deterministic	Computed from monthly samples using MPN method	J. Cavalier, NCDENR, e-mail communication, March 21, 2014
Ratio of <i>E. coli</i> to total coliform concentration	$R_{EC:TC}$			
Step 1: Simulate correlated, paired total coliform (TC) and <i>E. coli</i> (EC) concentrations (CFU/100 ml)	TC, EC	Bivariate lognormal	Surface water: TC median=1,200, geometric sd=8.43; EC median=280, geometric sd=5.29, correlation=0.85 Groundwater: TC median=3.5, geometric sd=5.56; EC median=1, geometric sd=15.3, correlation=0.9	Embrey and Runkle 2006; Francy et al. 2000
Step 2: Calculate <i>E. coli</i> -to-total coliform ratio from simulated, paired concentrations	$R_{EC:TC}$	EC/TC	NA	NA
<i>E. coli</i> presence in CWS i , month j , conditional on total coliform presence	$p_{EC TC}$	Deterministic	Computed as percentage of monthly samples testing positive for total coliforms that also tested positive for <i>E. coli</i>	J. Cavalier, NCDENR, e-mail communication, March 21, 2014
<i>E. coli</i> concentration in CWS i , month j	$\mu_{i,j}$	Poisson	mean= $p_{EC TC} * \mu TC_{i,j} * R_{EC:TC}$	
Pathogen-to- <i>E. coli</i> ratios	$R_{pathogen}$	Lognormal	Surface water: <i>Giardia</i> 0.033 (0.024), <i>Campylobacter</i> 0.20 (0.13), rotavirus 0.0070 (0.0045); groundwater rotavirus 0.36 (1.4)	Hein Van Lieverloo, e-mail, June 17, 2014

Table S4. Dose-response and morbidity data used in quantitative microbial risk assessment

Reference Pathogen	Dose-Response Model	Model Parameters	Morbidity Ratio	Reference
<i>Girardia</i>	Exponential	Lognormal (0.0199,0.066)*	Triangular (0.39, 0.58, 0.91)	Rose et al. 1993
<i>Campylobacter</i>	Beta-Poisson	Bivariate lognormal: α (0.024,0.03),* β (0.011, 0.04),* correlation (α , β) = 0.82	$\alpha/(\alpha+\beta)$	Teunis et al. 2005; Evans et al. 1996; Van den Brandhof, 2003
Rotavirus	Beta-Poisson	Bivariate lognormal: α (0.265,0.08),* β (0.442, 1.2), * correlation (α , β) = 0.74	Triangular (0.01, 0.5, 0.97)	Haas et al. 1993; Schiff et al. 1984

* Mean and standard deviation (not log transformed).

Table S5. County estimates of ED visits for AGI and total AGI cases attributable to microbial contamination in CWSs per 10,000 people (mean and 95% confidence interval)

County	PIM			DWAR			QMRA		
	AGI ED Visits Attributable to CWSs	Total Attributable AGI Cases	Rank ^a	AGI ED Visits Attributable to CWSs	Total Attributable AGI Cases	Rank ^a	AGI ED Visits Attributable to CWSs	Total Attributable AGI Cases	Rank ^a
ALAMANCE	0.059 (0.029- 0.089)	0.95 (0.47- 1.4)	57	32 (28-36)	510 (450-580)	34	0.0039 (0-0.026)	0.062 (0-0.42)	71
ALEXANDER	0 (0-0)	0 (0-0)	1	33 (22-43)	530 (350-690)	38	0 (0-0)	0 (0-0)	1
ALLEGHANY	0.16 (0.13-0.2)	2.6 (2-3.2)	84	64 (58-70)	1000 (930- 1100)	83	1.5 (0-12)	24 (0-190)	96
ANSON	0.47 (0.38- 0.55)	7.5 (6.1-8.8)	97	120 (110-130)	1900 (1800- 2100)	98	19 (0-82)	300 (0-1300)	100
ASHE	0 (0-0)	0 (0-0)	1	32 (24-40)	510 (380-640)	34	0 (0-0)	0 (0-0)	1
AVERY	0.0045 (0.0022- 0.0068)	0.072 (0.035- 0.11)	26	26 (22-30)	420 (350-480)	18	0 (0-0)	0 (0-0)	1

County	PIM			DWAR			QMRA		
	AGI ED Visits Attributable to CWSs	Total Attributable AGI Cases	Rank ^a	AGI ED Visits Attributable to CWSs	Total Attributable AGI Cases	Rank ^a	AGI ED Visits Attributable to CWSs	Total Attributable AGI Cases	Rank ^a
BEAUFORT	0.13 (0.066-0.2)	2.2 (1.1-3.2)	79	91 (82-110)	1500 (1300-1800)	94	0 (0-0)	0 (0-0)	1
BERTIE	0.29 (0.14-0.44)	4.7 (2.3-7)	93	120 (100-150)	1900 (1600-2400)	98	0 (0-0)	0 (0-0)	1
BLADEN	0.06 (0.03-0.09)	0.96 (0.47-1.4)	58	50 (46-53)	800 (740-850)	70	0 (0-0)	0 (0-0)	1
BRUNSWICK	0.0079 (0.0039-0.012)	0.13 (0.062-0.19)	31	32 (24-39)	510 (380-620)	34	0 (0-0)	0 (0-0)	1
BUNCOMBE	0.1 (0.05-0.15)	1.6 (0.8-2.4)	73	28 (26-31)	450 (420-500)	23	0 (0-0)	0 (0-0)	1
BURKE	0 (0-0)	0 (0-0)	1	48 (36-58)	770 (580-930)	66	0 (0-0)	0 (0-0)	1
CABARRUS	0.037 (0.019-0.056)	0.6 (0.3-0.89)	47	28 (19-35)	450 (300-560)	23	0.012 (0-0.12)	0.19 (0-1.9)	75
CALDWELL	0 (0-0)	0 (0-0)	1	48 (37-59)	770 (590-940)	66	0 (0-0)	0 (0-0)	1
CAMDEN	0 (0-0)	0 (0-0)	1	15 (9.3-20)	240 (150-320)	4	0 (0-0)	0 (0-0)	1
CARTERET	0.23 (0.14-0.31)	3.7 (2.3-5)	90	110 (110-120)	1800 (1800-1900)	97	0.99 (0-9.4)	16 (0-150)	92
CASWELL	0.017 (0.0082-0.025)	0.27 (0.13-0.4)	39	22 (20-25)	350 (320-400)	12	0 (0-0)	0 (0-0)	1
CATAWBA	0.0001 (0.00005-0.00015)	0.0016 (0.00081-0.0025)	13	33 (23-41)	530 (370-660)	38	0 (0-0)	0 (0-0)	1
CHATHAM	0.022 (0.011-0.033)	0.35 (0.17-0.52)	42	21 (18-23)	340 (290-370)	11	0.0059 (0-0.038)	0.094 (0-0.61)	72
CHEROKEE	0.0038 (0.0019-0.0057)	0.061 (0.03-0.091)	25	18 (13-23)	290 (210-370)	7	0 (0-0)	0 (0-0)	1
CHOWAN	0.42 (0.3-0.52)	6.7 (4.9-8.3)	96	100 (96-110)	1600 (1500-1800)	96	1.7 (0-19)	27 (0-300)	97
CLAY	0 (0-0)	0 (0-0)	1	11 (6.7-14)	180 (110-220)	1	0 (0-0)	0 (0-0)	1
CLEVELAND	0.014 (0.0068-0.021)	0.22 (0.11-0.33)	35	45 (34-55)	720 (540-880)	63	0 (0-0)	0 (0-0)	1
COLUMBUS	0.29 (0.22-0.35)	4.6 (3.6-5.5)	92	85 (75-100)	1400 (1200-1600)	92	2.8 (0-21)	45 (0-340)	99

County	PIM			DWAR			QMRA		
	AGI ED Visits Attributable to CWSs	Total Attributable AGI Cases	Rank ^a	AGI ED Visits Attributable to CWSs	Total Attributable AGI Cases	Rank ^a	AGI ED Visits Attributable to CWSs	Total Attributable AGI Cases	Rank ^a
CRAVEN	0.11 (0.055- 0.17)	1.8 (0.88-2.7)	76	93 (83-100)	1500 (1300- 1600)	95	0 (0-0)	0 (0-0)	1
CUMBERLAND	0.077 (0.048- 0.11)	1.2 (0.76-1.7)	68	25 (18-31)	400 (290-500)	17	0.33 (0-2.1)	5.3 (0-34)	86
CURRITUCK	0.0035 (0.0017- 0.0053)	0.056 (0.028- 0.085)	24	13 (9.9-17)	210 (160-270)	2	0 (0-0)	0 (0-0)	1
DARE	0.076 (0.037- 0.11)	1.2 (0.6-1.8)	67	54 (52-57)	860 (830-910)	73	0 (0-0)	0 (0-0)	1
DAVIDSON	0.04 (0.02- 0.06)	0.64 (0.32- 0.96)	50	42 (31-53)	670 (500-850)	60	0 (0-0)	0 (0-0)	1
DAVIE	0.015 (0.0072- 0.022)	0.23 (0.12- 0.35)	36	55 (48-73)	880 (770- 1200)	75	0 (0-0)	0 (0-0)	1
DUPLIN	0.00049 (0.00024- 0.00074)	0.0079 (0.0039- 0.012)	17	28 (20-34)	450 (320-540)	23	0 (0-0)	0 (0-0)	1
DURHAM	0.18 (0.16- 0.21)	3 (2.6-3.3)	86	47 (42-53)	750 (670-850)	64	0.11 (0-0.31)	1.8 (0-5)	82
EDGECOMBE	0.2 (0.099-0.3)	3.2 (1.6-4.9)	87	61 (55-73)	980 (880- 1200)	80	0 (0-0)	0 (0-0)	1
FORSYTH	0.029 (0.014- 0.043)	0.46 (0.23- 0.69)	44	26 (13-37)	420 (210-590)	18	0.011 (0-0.074)	0.18 (0-1.2)	74
FRANKLIN	0.06 (0.03- 0.09)	0.97 (0.49- 1.4)	59	34 (31-36)	540 (500-580)	42	0.013 (0-0.12)	0.21 (0-1.9)	76
GASTON	0.035 (0.017- 0.052)	0.56 (0.27- 0.84)	46	40 (32-48)	640 (510-770)	57	0 (0-0)	0 (0-0)	1
GATES	0.048 (0.024- 0.073)	0.77 (0.38- 1.2)	54	20 (19-21)	320 (300-340)	8	0 (0-0)	0 (0-0)	1
GRAHAM	0 (0-0)	0 (0-0)	1	20 (13-26)	320 (210-420)	8	0 (0-0)	0 (0-0)	1
GRANVILLE	0.015 (0.0076- 0.023)	0.25 (0.12- 0.37)	38	34 (26-41)	540 (420-660)	42	0 (0-0)	0 (0-0)	1
GREENE	0.029 (0.014- 0.043)	0.46 (0.23- 0.69)	43	34 (32-36)	540 (510-580)	42	0 (0-0)	0 (0-0)	1

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GUILFORD	0.23 (0.12-0.35)	3.7 (1.8-5.6)	91	41 (36-46)	660 (580-740)	59	0.0032 (0-0.03)	0.051 (0-0.48)	70
HALIFAX	0.096 (0.047-0.14)	1.5 (0.76-2.3)	70	130 (120-140)	2100 (1900-2200)	100	0 (0-0)	0 (0-0)	1
HARNETT	0.042 (0.021-0.064)	0.68 (0.33-1)	52	36 (34-39)	580 (540-620)	47	0 (0-0)	0 (0-0)	1
HAYWOOD	0.12 (0.097-0.13)	1.8 (1.5-2.1)	77	34 (31-37)	540 (500-590)	42	1 (0-7.2)	16 (0-120)	93
HENDERSON	0.0014 (0.00069-0.0021)	0.023 (0.011-0.034)	22	38 (34-42)	610 (540-670)	53	0 (0-0)	0 (0-0)	1
HERTFORD	0.16 (0.13-0.2)	2.6 (2-3.2)	85	38 (35-41)	610 (560-660)	53	2.1 (0-15)	34 (0-240)	98
HOKE	0.048 (0.024-0.073)	0.78 (0.38-1.2)	55	61 (54-75)	980 (860-1200)	80	0 (0-0)	0 (0-0)	1
HYDE	0.1 (0.049-0.15)	1.6 (0.79-2.4)	72	39 (36-42)	620 (580-670)	56	0 (0-0)	0 (0-0)	1
IREDELL	0.16 (0.14-0.18)	2.6 (2.2-2.9)	83	65 (58-77)	1000 (930-1200)	86	0.48 (0-6.4)	7.7 (0-100)	89
JACKSON	0.0051 (0.003-0.0071)	0.081 (0.048-0.11)	28	22 (17-27)	350 (270-430)	12	0.0067 (0-0.083)	0.11 (0-1.3)	73
JOHNSTON	0.31 (0.23-0.38)	4.9 (3.7-6.1)	94	58 (47-67)	930 (750-1100)	77	0.81 (0-6.9)	13 (0-110)	90
JONES	0.042 (0.021-0.063)	0.67 (0.33-1)	51	64 (58-71)	1000 (930-1100)	83	0 (0-0)	0 (0-0)	1
LEE	0.11 (0.054-0.17)	1.8 (0.87-2.7)	75	23 (14-31)	370 (220-500)	15	0 (0-0)	0 (0-0)	1
LENOIR	0.011 (0.0052-0.016)	0.17 (0.083-0.25)	33	69 (54-83)	1100 (860-1300)	88	0 (0-0)	0 (0-0)	1
LINCOLN	0 (0-0)	0 (0-0)	1	36 (30-41)	580 (480-660)	47	0 (0-0)	0 (0-0)	1
MACON	0.00066 (0.00033-0.001)	0.011 (0.0052-0.016)	18	29 (21-37)	460 (340-590)	28	0 (0-0)	0 (0-0)	1
MADISON	0.0069 (0.0034-0.01)	0.11 (0.055-0.17)	30	16 (14-19)	260 (220-300)	5	0 (0-0)	0 (0-0)	1

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MARTIN	0.21 (0.1-0.32)	3.4 (1.7-5.1)	88	54 (50-59)	860 (800-940)	73	0 (0-0)	0 (0-0)	1
MCDOWELL	0.047 (0.039- 0.055)	0.75 (0.62- 0.88)	53	64 (60-70)	1000 (960- 1100)	83	1.1 (0-7.5)	18 (0-120)	94
MECKLENBURG	0.89 (0.62-1.1)	14 (9.9-18)	100	40 (37-43)	640 (590-690)	57	0.29 (0-1.9)	4.6 (0-30)	85
MITCHELL	0 (0-0)	0 (0-0)	1	60 (53-67)	960 (850- 1100)	78	0 (0-0)	0 (0-0)	1
MONTGOMERY	0.067 (0.033- 0.1)	1.1 (0.53-1.6)	63	55 (47-71)	880 (750- 1100)	75	0 (0-0)	0 (0-0)	1
MOORE	0.038 (0.022- 0.054)	0.61 (0.35- 0.86)	48	43 (40-46)	690 (640-740)	62	0.098 (0-0.89)	1.6 (0-14)	80
NASH	0.093 (0.046- 0.14)	1.5 (0.73-2.2)	69	28 (27-30)	450 (430-480)	23	0 (0-0)	0 (0-0)	1
NEW HANOVER	0.16 (0.086- 0.23)	2.5 (1.4-3.7)	82	37 (27-46)	590 (430-740)	51	0.1 (0-1.1)	1.6 (0-18)	81
NORTHAMPTON	0.057 (0.028- 0.085)	0.91 (0.45- 1.4)	56	82 (77-87)	1300 (1200- 1400)	91	0 (0-0)	0 (0-0)	1
ONslow	0.48 (0.32- 0.64)	7.7 (5.1-10)	98	62 (57-67)	990 (910- 1100)	82	0.23 (0-0.012)	3.7 (0-0.19)	84
ORANGE	0.061 (0.038- 0.084)	0.97 (0.6-1.3)	60	16 (10-21)	260 (160-340)	5	0.083 (0-0.99)	1.3 (0-16)	79
PAMLICO	0.15 (0.073- 0.22)	2.4 (1.2-3.6)	80	74 (64-100)	1200 (1000- 1600)	90	0 (0-0)	0 (0-0)	1
PASQUOTANK	0 (0-0)	0 (0-0)	1	26 (16-35)	420 (260-560)	18	0 (0-0)	0 (0-0)	1
PENDER	0.02 (0.01- 0.03)	0.32 (0.16- 0.49)	41	30 (24-36)	480 (380-580)	31	0 (0-0)	0 (0-0)	1
PERQUIMANS	0.12 (0.059- 0.18)	1.9 (0.95-2.9)	78	66 (56-89)	1100 (900- 1400)	87	0 (0-0)	0 (0-0)	1
PERSON	0.00013 (0.000065- 0.0002)	0.0021 (0.001- 0.0032)	14	29 (14-41)	460 (220-660)	28	0 (0-0)	0 (0-0)	1
PITT	0.33 (0.27- 0.39)	5.3 (4.3-6.2)	95	48 (45-52)	770 (720-830)	66	1.1 (0-11)	18 (0-180)	95
POLK	0.01 (0.0051- 0.016)	0.16 (0.081- 0.25)	32	30 (21-38)	480 (340-610)	31	0 (0-0)	0 (0-0)	1

County	PIM	DWAR			QMRA			Rank ^a	
	AGI ED Visits Attributable to CWSs	Total Attributable AGI Cases	Rank ^a	AGI ED Visits Attributable to CWSs	Total Attributable AGI Cases	Rank ^a	AGI ED Visits Attributable to CWSs		Total Attributable AGI Cases
RANDOLPH	0.075 (0.038-0.11)	1.2 (0.61-1.8)	66	53 (49-59)	850 (780-940)	72	0.036 (0-0.25)	0.58 (0-4)	77
RICHMOND	0.011 (0.0053-0.016)	0.17 (0.085-0.26)	34	32 (24-39)	510 (380-620)	34	0 (0-0)	0 (0-0)	1
ROBESON	0.02 (0.016-0.023)	0.31 (0.26-0.37)	40	42 (28-53)	670 (450-850)	60	0.22 (0-2.1)	3.5 (0-34)	83
ROCKINGHAM	0.074 (0.037-0.11)	1.2 (0.58-1.8)	65	88 (77-110)	1400 (1200-1800)	93	0 (0-0)	0 (0-0)	1
ROWAN	0.066 (0.033-0.1)	1.1 (0.52-1.6)	62	23 (16-30)	370 (260-480)	15	0.002 (0-0.014)	0.032 (0-0.22)	69
RUTHERFORD	0.061 (0.03-0.092)	0.98 (0.48-1.5)	61	47 (41-53)	750 (660-850)	64	0 (0-0)	0 (0-0)	1
SAMPSON	0.006 (0.0029-0.009)	0.095 (0.047-0.14)	29	36 (27-43)	580 (430-690)	47	0 (0-0)	0 (0-0)	1
SCOTLAND	0 (0-0)	0 (0-0)	1	37 (23-49)	590 (370-780)	51	0 (0-0)	0 (0-0)	1
STANLY	0.068 (0.034-0.1)	1.1 (0.54-1.6)	64	36 (31-41)	580 (500-660)	47	0 (0-0)	0 (0-0)	1
STOKES	0.00097 (0.00048-0.0015)	0.016 (0.0077-0.023)	20	29 (16-40)	460 (260-640)	28	0 (0-0)	0 (0-0)	1
SURRY	0.029 (0.015-0.044)	0.47 (0.23-0.71)	45	49 (39-58)	780 (620-930)	69	0 (0-0)	0 (0-0)	1
SWAIN	0.00068 (0.00033-0.001)	0.011 (0.0053-0.016)	19	33 (19-44)	530 (300-700)	38	0 (0-0)	0 (0-0)	1
TRANSYLVANIA	0.0012 (0.0006-0.0018)	0.02 (0.0096-0.029)	21	26 (18-33)	420 (290-530)	18	0 (0-0)	0 (0-0)	1
TYRRELL	0.097 (0.048-0.15)	1.6 (0.77-2.3)	71	50 (47-53)	800 (750-850)	70	0 (0-0)	0 (0-0)	1
UNION	0.00048 (0.00023-0.00072)	0.0076 (0.0038-0.011)	16	20 (13-28)	320 (210-450)	8	0 (0-0)	0 (0-0)	1

County	PIM			DWAR			QMRA		
	AGI ED Visits Attributable to CWSs	Total Attributable AGI Cases	Rank ^a	AGI ED Visits Attributable to CWSs	Total Attributable AGI Cases	Rank ^a	AGI ED Visits Attributable to CWSs	Total Attributable AGI Cases	Rank ^a
VANCE	0.0049 (0.0041- 0.0057)	0.079 (0.065- 0.092)	27	27 (15-38)	430 (240-610)	22	0.08 (0-0.59)	1.3 (0-9.4)	78
WAKE	0.61 (0.42- 0.79)	9.7 (6.6-13)	99	60 (57-65)	960 (910- 1000)	78	0.43 (0-3.5)	6.9 (0-56)	87
WARREN	0.1 (0.051- 0.16)	1.7 (0.82-2.5)	74	35 (34-37)	560 (540-590)	46	0 (0-0)	0 (0-0)	1
WASHINGTON	0.039 (0.019- 0.059)	0.63 (0.31- 0.95)	49	33 (31-35)	530 (500-560)	38	0 (0-0)	0 (0-0)	1
WATAUGA	0.0022 (0.0011- 0.0033)	0.035 (0.017- 0.053)	23	14 (11-18)	220 (180-290)	3	0 (0-0)	0 (0-0)	1
WAYNE	0.23 (0.17- 0.28)	3.7 (2.8-4.5)	89	72 (68-77)	1200 (1100- 1200)	89	0.46 (0-5.4)	7.4 (0-86)	88
WILKES	0.0002 (0.0001- 0.00031)	0.0033 (0.0016- 0.0049)	15	22 (17-27)	350 (270-430)	12	0 (0-0)	0 (0-0)	1
WILSON	0.015 (0.0074- 0.023)	0.24 (0.12- 0.36)	37	30 (20-39)	480 (320-620)	31	0 (0-0)	0 (0-0)	1
YADKIN	0.16 (0.12- 0.19)	2.5 (1.9-3)	81	38 (33-43)	610 (530-690)	53	0.92 (0-9.6)	15 (0-150)	91
YANCEY	0 (0-0)	0 (0-0)	1	28 (17-37)	450 (270-590)	23	0 (0-0)	0 (0-0)	1

^aRelative ranking by AGI attributable visits per 10,000 people among all 100 NC counties. Rank=1 indicates county in which attributable number of cases per person is lowest among all counties.

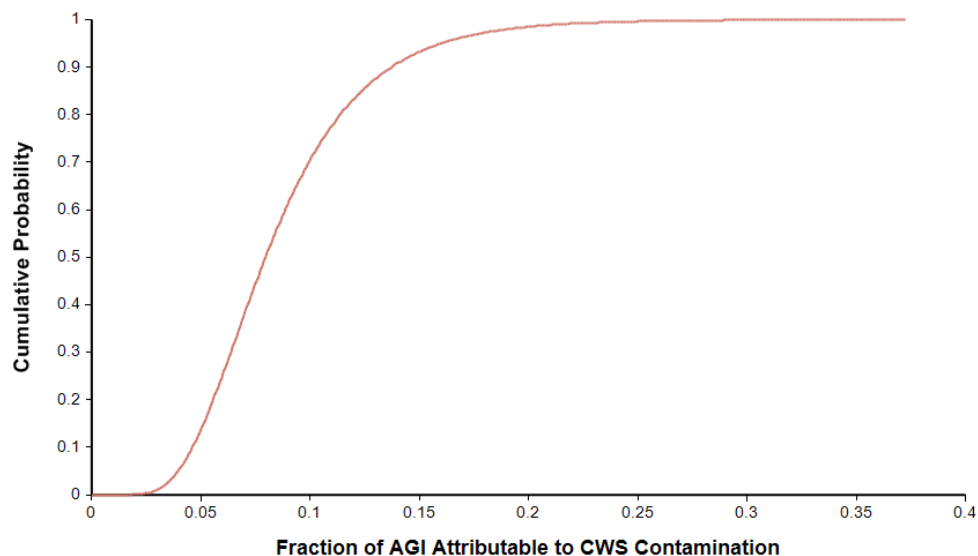


Figure S1. Cumulative probability distribution representing the fraction of acute gastrointestinal illness (AGI) cases attributable to microbial contamination of drinking water in a randomly selected community water system. SOURCE: Derived from simulations using data and methods described in Messner et al. 2006, Appendix A.

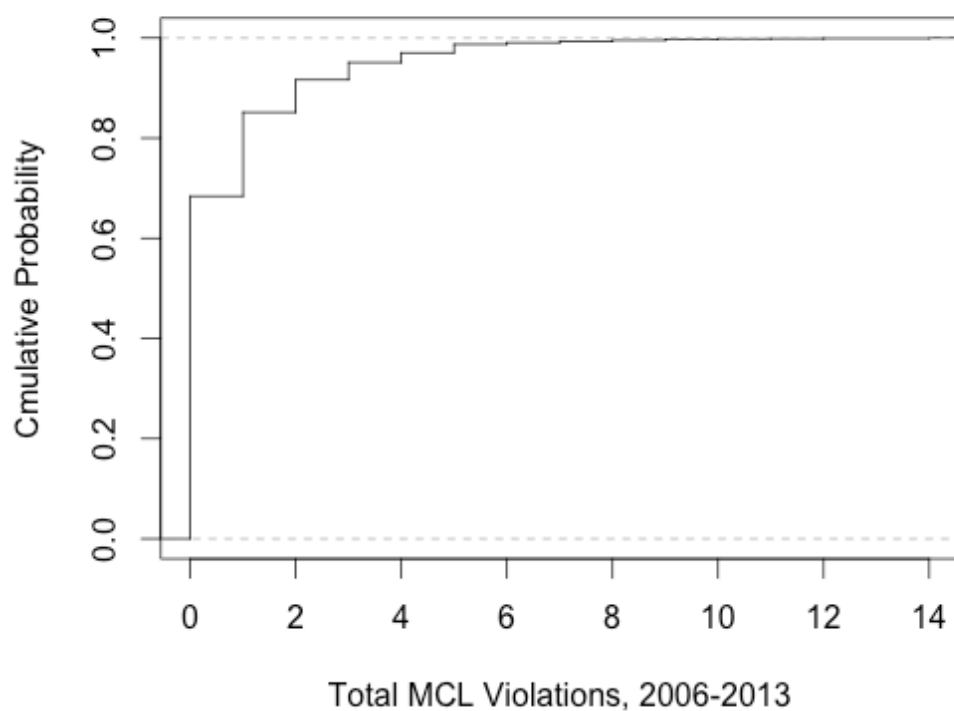


Figure S2. Empirical cumulative distribution of number maximum contaminant level (MCL) violations among the 2,120 community water systems in North Carolina during 2006-2013.

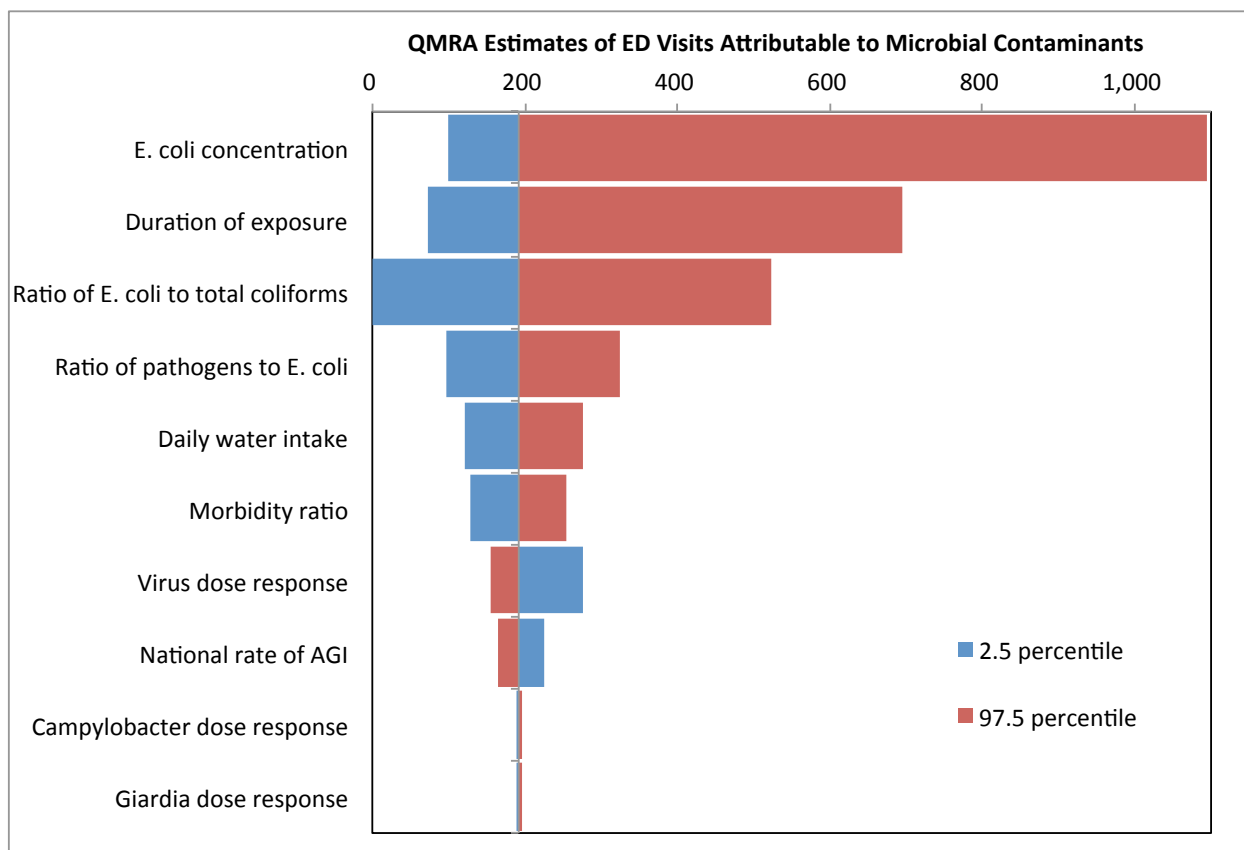


Figure S3. Sensitivity of the risk estimates to changes in input variables of the quantitative microbial risk assessment (QMRA) model. The red and blue bars show the effect on the median risk estimate of changing each uncertain input variable to the lower or upper end of its 95% confidence interval value. ED: emergency department.

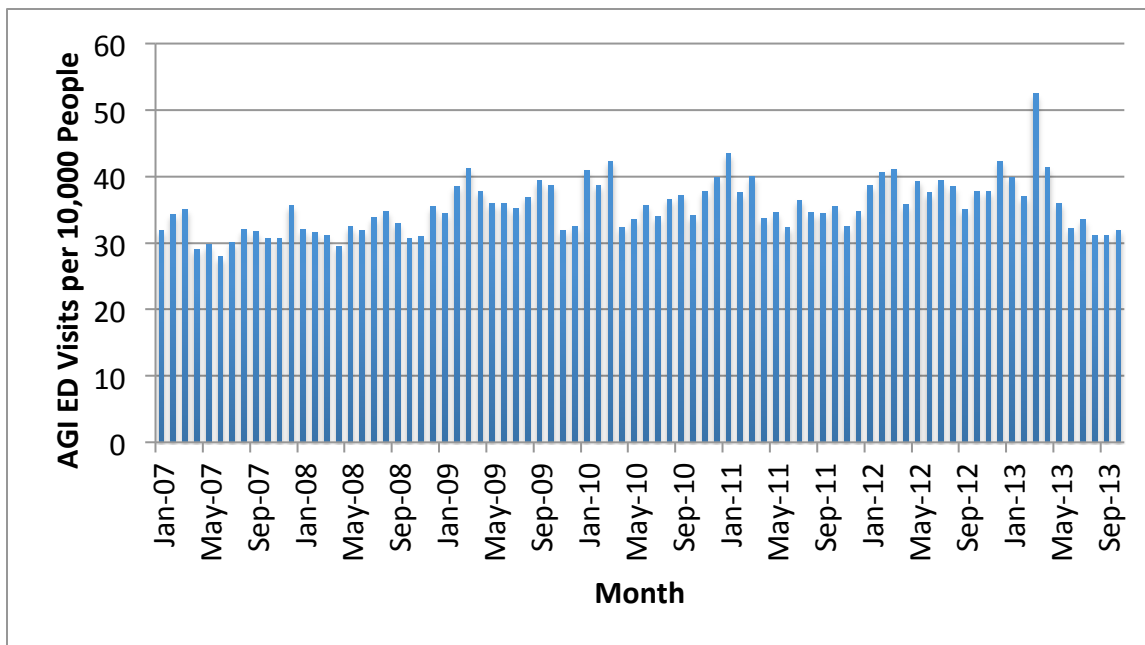


Figure S4. Monthly incidence rates of emergency department (ED) visits for acute gastrointestinal illness (AGI) per 10,000 people. Incidence rates are higher in winter months (December–March) than in summer (July–September).

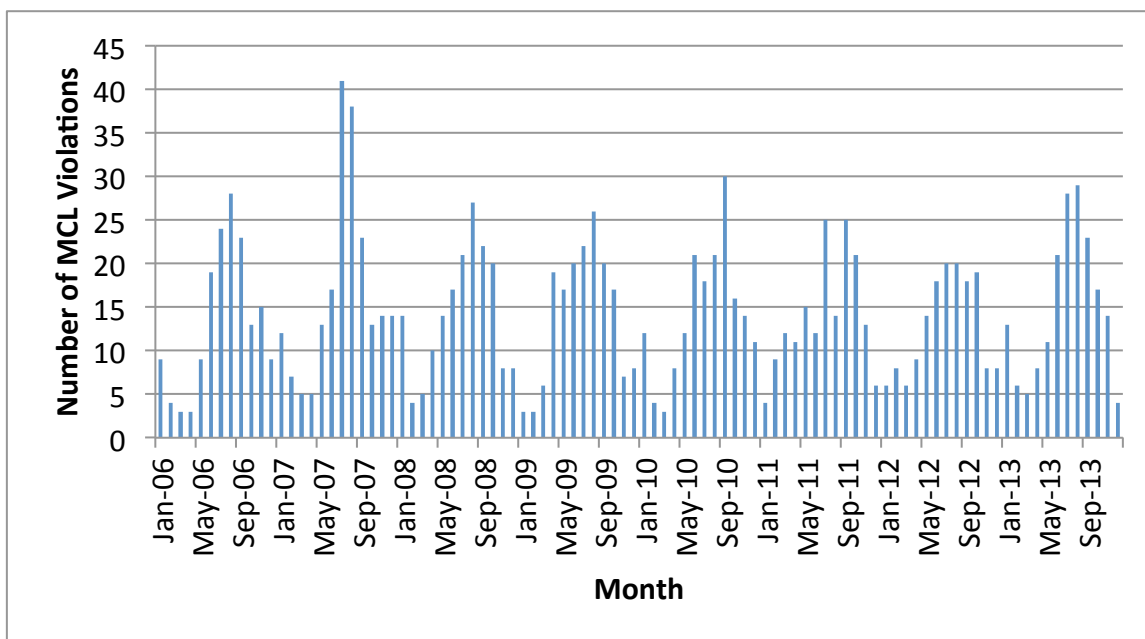


Figure S5. Violations of the Safe Drinking Water Act monthly Maximum Contaminant Levels (MCLs) for coliform bacteria in North Carolina community water supply systems (total for all systems). Violation rates are higher in summer months (July–September) than in winter (December–March).

REFERENCES

- Cavalier, J. North Carolina Department of Environment and Natural Resources Public Water Supply Section, contact via phone and e-mail, March 21, 2014.
- Embrey, S.S. and Runkle, D.L. Microbial Quality of the Nation's Ground-water Resources, 1993-2004. US Department of the Interior, US Geological Survey: 2006.
- Evans, M.; Roberts, R.; Ribeiro, C.; Gardner, D.; Kembrey, D. A milk-borne *Campylobacter* outbreak following an educational farm visit. *Epidemiol. Infect.* 1996, 117 (03), 457-462.
- Francy, D.S.; Helsel, D.R.; Nally, R.A. Occurrence and distribution of microbiological indicators in groundwater and stream water. *Water Environ. Res.* 2000, 152-161.
- Gerba, C.P.; Rose, J.B.; Haas, C.N.; Crabtree, K.D. Waterborne rotavirus: a risk assessment. *Water Res.* 1996, 30 (12), 2929-2940.
- Haas, C.N.; Rose, J.B.; Gerba, C.; Regli, S. Risk assessment of virus in drinking water. *Risk Analysis* 1993, 13 (5), 545-552.
- Jones, T. F. et al. A population-based estimate of the substantial burden of diarrhoeal disease in the United States; FoodNet, 1996-2003. *Epidemiol. Infect.* 2007, 135, 293-301.
- Messner, M. et al. An approach for developing a national estimate of waterborne disease due to drinking water and a national estimate model application. *J. Water Health* 2006, 04 (Suppl. 2), 201-240.
- Regli, S.; Rose, J.B.; Haas, C.N.; Gerba, C.P. Modeling the risk from *Giardia* and viruses in drinking water. *Journal (American Water Works Association)* 1991, 76-84.
- Rose, J.B.; Haas, C.N.; Regli, S. Risk assessment and control of waterborne giardiasis. *Am. J. Public Health* 1991, 81 (6), 709-713.
- Roseberry, A. M. & Burmaster, D. E. Lognormal distributions for water intake by children and adults. *Risk Anal.* 1992, 12, 99-104.
- Scallan, E. et al. Foodborne illness acquired in the United States—major pathogens. *Emerg. Infect. Dis.* 2011a, 17, 7-15.
- Scallan, E., Griffin, P. M., Angulo, F. J., Tauxe, R. V & Hoekstra, R. M. Foodborne illness acquired in the United States--unspecified agents. *Emerg. Infect. Dis.* 2011b, 17, 16-22.
- Schiff, G.M.; Stefanovic, G.M.; Young, E.C.; Sander, D.S.; Pennekamp, J.K.; Ward, R.L. Studies of echovirus-12 in volunteers: determination of minimal infectious dose and the effect of previous infection on infectious dose. *J. Infect. Dis.* 1984, 150 (6), 858-866.
- Teunis, P.; Van den Brandhof, W.; Nauta, M.; Wagenaar, J.; Van den Kerkhof, H.; Van Pelt, W. A reconsideration of the *Campylobacter* dose-response relation. *Epidemiol. Infect.* 2005, 133 (04), 583-592.
- Van den Brandhof, W.; Wagenaar, J.; Van den Kerkhof, H. An outbreak of campylobacteriosis after drinking pasteurized milk, 2002, The Netherlands. *International Journal of Medical Microbiology* 2003, 293 (S35), 142.
- Van Lieverloo, J. H. M., Blokker, E. J. M. & Medema, G. Quantitative microbial risk assessment of distributed drinking water using faecal indicator incidence and concentrations. *J. Water Health* 2007 (Suppl. 1), 131-49.
- Van Lieverloo, J. H., Viaeterna, contact via email June 17, 2014.