Phenomenological risk assessment of sporadic listeriosis outbreaks

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Introduction

A main obstacle for the risk assessment of listeriosis is the hardly known dose-response relation. In fact, human volunteer studies are not feasible and effects observed in animals are difficult to relate to humans. We show how to evaluate the risk by means of data from illness reports and monitoring programs.

Materials and Methods

The listeriosis incidence rate (I) reflects exposition and susceptibility of the population simultaneously. If I is below 8 cases per million of population and per year (CH: I=3.5), then the outbreak is considered as sporadic (Bille & Bannerman 2001). The listeriosis susceptibility however can be evaluated separately using the quotas of groups at risk and the likelihood and severity of diseases per group at risk.

The two groups at risk "pregnant women" (perinatal cases) and "susceptive adults" cover 90% of the listeriosis cases (Bille & Bannerman 2001; Schwartz et al. 1988; Gellin et al. 1987). The quota of perinatal listeriosis cases in an area can be related to the birth rates [br(area)] by interpolation/regression technique:

$$L(br(area)) = \frac{39\% - 14\%}{br(LA) - br(CH)}(br(area) - br(CH)) + 14\%$$

where LA and CH refer to listeriosis monitoring programs in Los Angeles County (Mascola et al. 1989) and Switzerland (Bille & Bannerman 2001), with br(CH)=0.2 and br(LA)=0.35.

The severity and likelihood of diseases per group at risk are considered as a law of nature. Estimates for conditional probabilities of abort (CH: 28%), death of newborn (14.2%), handicapped newborn (57%), dead patient (24.6%) and handicapped patient (30.1%) given the group at risk are provided by the Swiss listeriosis monitoring program 1990-1999 (Bille & Bannerman 2001).

Table: Based on Buzby et al. (1996, Agricultural Economic Report No. 741) we apply our method in form of the following table

Annual risk per million of USA population ($)	Percentage of perinatal costs	Annual risk of the USA ($)	Incidence rate (I)	Population in millions (N)	Value of statistical life (VL)
776985	37.4%	249412185	5	321	1097792

	probabilities	hospitalization ($)	permanent treatment ($)	acute productivity loss ($)	chronic productivity loss ($)
Pregnant women	22.4%	12117 in 252 of 360 cases	0	1166 in 252 of 360 cases	
newborn/ fetuses	22.4%				
stillbirths/ abortions	18%	For the mother		40% of VL: 439117	
dead newborns	3.8%	48461		40% of VL: 439117	
survive healthily	66.3%	48461			
newborns with chronic *disability*:	11.9%				
total	20%	48461	506062		100%*VL: 1097792
moderate to severe	60%	48461	108092		93%*VL: 1020947
mild	20%	48461	43237		27%*VL: 296404
weighted perinatal costs	**total: 46303**	8712	3493	16278	17821
Non-pregnant adults	67.6%+ 10%:				
(90% with predisposition)	77.6%				
deaths among severe cases	34.5%	36344		274245	
survivals of severe cases	62.1%	36344	0	1548	
moderate cases	3.4%	12117	0	774	
weighted non-perinatal costs	**total: 109094**	29553	0	79541	0

The listeriosis risk characterization is given by I and the listeriosis susceptibility represented by the total probabilities of diseases: abort (CH: 3.92%), death of newborn (1.98%), handicapped newborn (7.98 %), dead patient (18.69%) and handicapped patient (22.87%). For example, I of dead newborn is I*7.98%=0.0693 and the annual number of dead newborn is N*I*7.98%=0.5 where N(CH)=7.2 Mio.

Risk is the sum of negative pecuniary consequences (costs of diseases) weighted by the likelihood of their occurrence (Kammen & Hassenzahl 1999). So

$$Risk_{Listeriosis} = I * \sum_{all\ diseases} \text{cost}(disease) * probability_{Listeriosis}(disease)$$

is the annual listeriosis risk per million of population (table).

Results and Discussion

Buzby et al. (1996) add systematically all listeriosis-related costs and find an annual total in the range from 232.7 to 264.4 millions (US-$, 1993). There numbers are consistent with Tappero et al. (1995), if N=321 and I=5.

So, according to our method the total annual costs are N*I*$Risk_{Listeriosis}$(USA)=$249.4 millions.

Conclusions

Applications that are now possible by our method:

Determination of the listeriosis risk per nation using nation-specific costs structures; Determination of the listeriosis risk per type of food.