

## Changes in the seasonal incidence of measles in Iceland, 1896–1974

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### SUMMARY

The changing seasonal patterns of reported measles cases in Iceland during this century are analysed. These changes are related to increased population mobility following the development of external and internal transport links, particularly since 1945. The forging of such links has resulted in a shift in the seasonal distribution of cases from one peculiar to the local social and economic conditions in Iceland to one broadly similar to that in other countries of northern temperate latitudes.

### INTRODUCTION

Yorke *et al.* (1979) have argued that whether or not a virus persists in a human population is determined largely by the degree of coincidence between (1) seasonal upswings in the amount of infection and (2) increases in the susceptible population above a critical threshold level. Clearly, if these two things are in phase, widespread infection is likely to occur; if they are not, there is an increased probability of fade-out of the disease. If Yorke *et al.* are correct in suggesting that an understanding of seasonal patterns of variation in disease intensity is a necessary prerequisite for the design of adequate control strategies, then the changing seasonal patterns in disease incidence are worth monitoring. In this note, we describe the seasonal patterns of reported measles cases in Iceland, 1896–1974, and show that they are not stable through time.

### MATERIALS AND METHODS

#### *Materials*

The measles records for Iceland have been analysed at length by Cliff *et al.* (1981) in a monograph on the spatial diffusion of epidemics and are summarized in a statistical appendix to that volume. Published monthly records of the number of reported cases of measles are available for more than 50 small geographical areas and go back in unbroken form to 1896. Although the reporting rate can be established only indirectly, it appears to be substantially better than that for England and Wales over comparable time periods (Cliff & Haggett, 1979). Certainly, Black

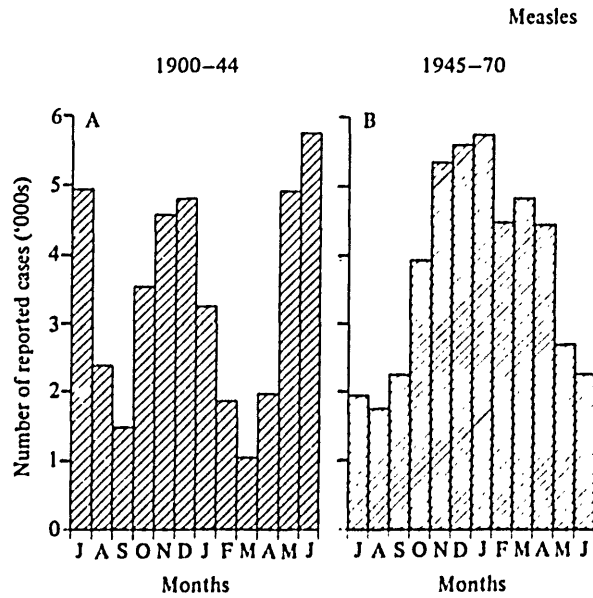


Fig. 1. Monthly distribution of measles cases. (A) 1900-44, (B) 1945-70. Sources: *Heilbrigðisskýrslur* (Public Health in Iceland), annual volumes.

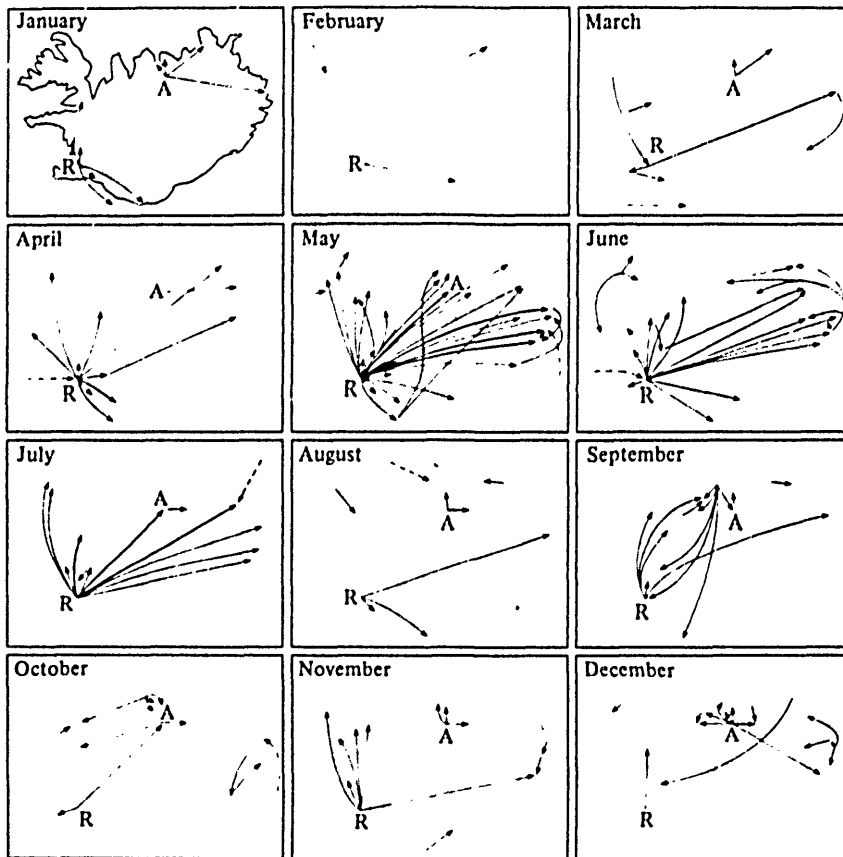


Fig. 2. All known movements of initial measles cases, 1896-1975, on a month-by-month basis. A = Akureyri, R = Reykjavik. Pecked arrows give places of introduction from overseas. Sources as for Fig. 1.

(1966) regarded Iceland as among the best documented of the 18 islands used in his comparative survey of measles epidemics.

To supplement the published record, there are available in the National Archive in Reykjavík written summaries of the course of each measles epidemic to have passed through the island. These summaries are prepared from the annual reports filed in Reykjavík by the doctors in charge of public health in each medical district. The reports contain details of the size and severity of the various epidemics in each medical district. In addition, and crucially from a geographical point of view, many of the reports describe in some detail the spatial course of the epidemic in the medical districts. For such districts, information is given about the date of introduction of the disease into the district, where it came from, and which farms and other communities were subsequently infected. This level of detail makes the data uniquely valuable for the study of a diffusion process. In many cases, we have been able to reconstruct the actual history of a spread process.

### *Methods*

The materials available enable the seasonal pattern of measles to be looked at in two ways.

(1) The published data record has permitted the construction of histograms of the number of reported cases by month over the study period. This is the conventional way of examining seasonal patterns.

(2) The written accounts of the course of each epidemic have been used to prepare maps of the tracks of infection between medical districts on a monthly basis as recorded in these accounts.

### RESULTS

The results obtained from method (1) are shown in Fig. 1. Those from method (2) appear in Fig. 2; the arrowheads give the destination of an individual known to have introduced the disease into a particular medical district in the month in question, while the arrow bases give the origin. Note that each arrow simply connects the place of origin of an infected individual with the destination district. In the earlier periods, most population movements would have been around the coast by means of local shipping. No attempt has been made to show these circumferential movements in Fig. 2.

### DISCUSSION

The standard accounts of measles frequently ascribe to it a strong seasonal pattern. Thus Ball (1977, pp. 245–6) describes the measles as having ‘a higher incidence in the colder months, reaching a peak in January and February which is most marked in an epidemic year’. Yorke *et al.* (1979, p. 104) show that, in the United States, measles peaks in early spring. This ‘beginning-of-year peak’ generalization is based on northern temperate countries and we should expect the corresponding months to be July and August in the southern temperate countries. Ball notes a less regular pattern in tropical countries. In India, for example, the peak incidence is in the hot, dry period from March to June.

Variations in infection rates are *not* generally ascribed to the primary effects on the measles virus of temperature and humidity fluctuations, but rather to the secondary effects of such fluctuations on the susceptible population. Thus, in Britain, which also has a January–February epidemic peak, this may relate to the opening of schools in early January after the Christmas holidays (itself a period of high contact between members of families) plus the two- or three-week lag while index cases are incubating and spreading the disease.

In the case of Iceland, the monthly distribution of cases is an interesting one. For the period since 1945, Fig. 1B shows a seasonal pattern much like that suggested by Ball, with a January peak and a marked concentration of cases in the winter half of the year. The period 1900–44, is, however, a strongly contrasting one (Fig. 1A); the seasonal distribution is bimodal, with distinct peaks in December and again in June.

Any explanation of the Icelandic pattern must begin with the reminder that, since measles is not endemic in Iceland, the seasonal distribution will reflect the starting date of an epidemic. Of the seven measles epidemics studied which hit Iceland before World War II, all but one started in the first half of the year, so that a mid-year peak is not unexpected. It is suggested below that this concentration of starts early in the year may be related to improved boat and road links between regions after the spring thaw. Boat and road were the main means of travel up to 1945. In contrast, the nine post-war waves have starting months more randomly spread through the year. The haymaking season in Iceland peaks in June and this communal activity would be important in spreading the virus through a farm community, particularly in the earlier half of the century when farming families would form a large segment within the susceptible population. The persistent winter peak over the whole period probably reflects levels of crowding within school classrooms and the rapid spread within such institutions. Substantive evidence for this appears in Cliff *et al.* (1981, chapter 4).

If contacts at the school micro-spatial level were accelerated in winter, then contacts at the meso-level were retarded. For example, not only is public transport by bus between areas (there are no railways) substantially reduced in winter, but the network is dismembered, so that both north-west Iceland and north-east Iceland are cut off from the rest of the country. In considering the seasonal differences for Iceland, it is important to recall not only the extreme contrasts between winter and summer due to the climatic elements (for example, the blocking of roads by snow) but the effect of Arctic Circle location on day length. Reykjavík, the world's most poleward capital city, has less than six hours of daylight in midwinter.

Fig. 2 illustrates the seasonal effect in another way. The mushrooming of contacts in May is striking. These fall steadily through the summer and autumn to a winter quiet period. We need to bear in mind that most of the documentary information upon which Fig. 2 is based relates to the period between 1896 and 1944, so that Fig. 2 must reflect, in part, the improved transport in the summer months. For example, the seasonal patterns of the 1943 epidemic attracted comment from a number of district physicians. In *Heilbrigðisskýrslur* (Public Health in Iceland)

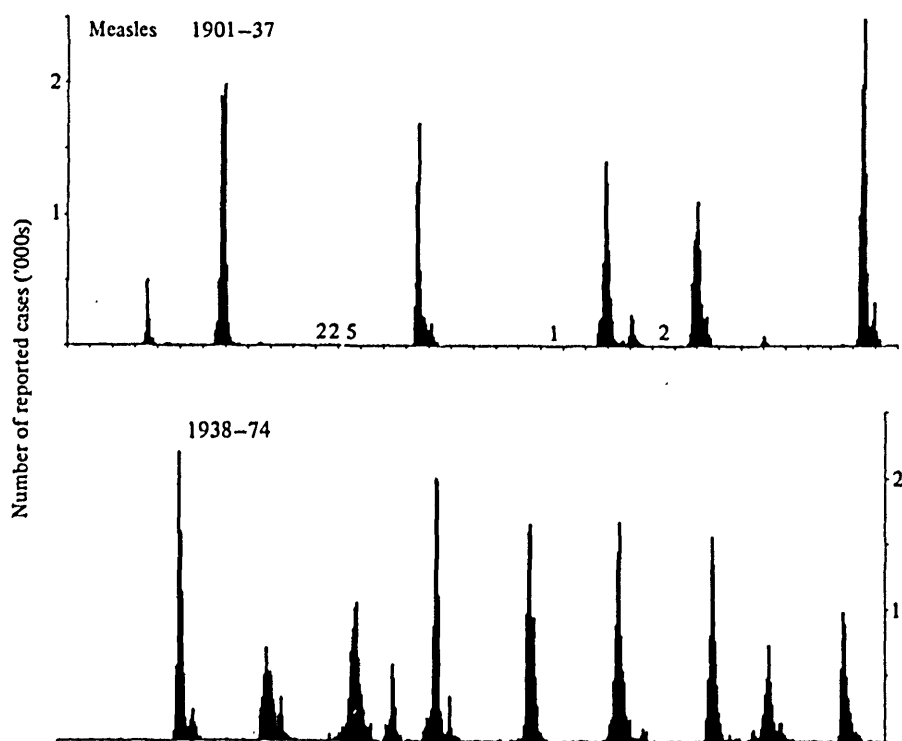


Fig. 3. Time series of reported cases of measles in thousands, Iceland 1901-74. Sources as for Fig. 1.

(1943, p. 32), the remark is made 'when people started to move about more and to come in from other districts [after the snow melt] then the disease appeared once again and spread considerably as summer came on'. The May peak on Fig. 2 is consistent with the June maximum of cases, 1900-44, shown on Fig. 1.

We may speculate that the shift in the seasonal distribution from a bimodal pattern, 1900-44, to the unimodal spring peak common in other nations of north-west Europe and North America is related to the decreased internal and external isolation of Iceland since 1945. The decades of relative isolation, in which the only external links were seaborne, were characterized by large measles epidemics (often with a distinct regional character as described in Cliff *et al.* (1981), section 4.3.2), separated by generally long quiet periods when the island was free of the virus. This is shown in Fig. 3. The decreasing size of epidemics is reinforced when it is known that the population of Iceland increased from roughly 70 000 to 210 000 over the period 1900-74. From 1945 onwards, any epidemiological isolation was increasingly broken down. Seaborne links with continental Europe were re-established, while air services brought an ever-larger flow of both Iceland-bound and transatlantic passengers into the international airport at Keflavík. Post-war measles waves were smaller than all the pre-war ones (except 1904-5) in terms of cases per thousand population, their timing was more frequent, and their regional concentration usually less pronounced. The long quiet periods between epidemics were shortened and the number of sporadic cases (outbreaks) in these gaps in-

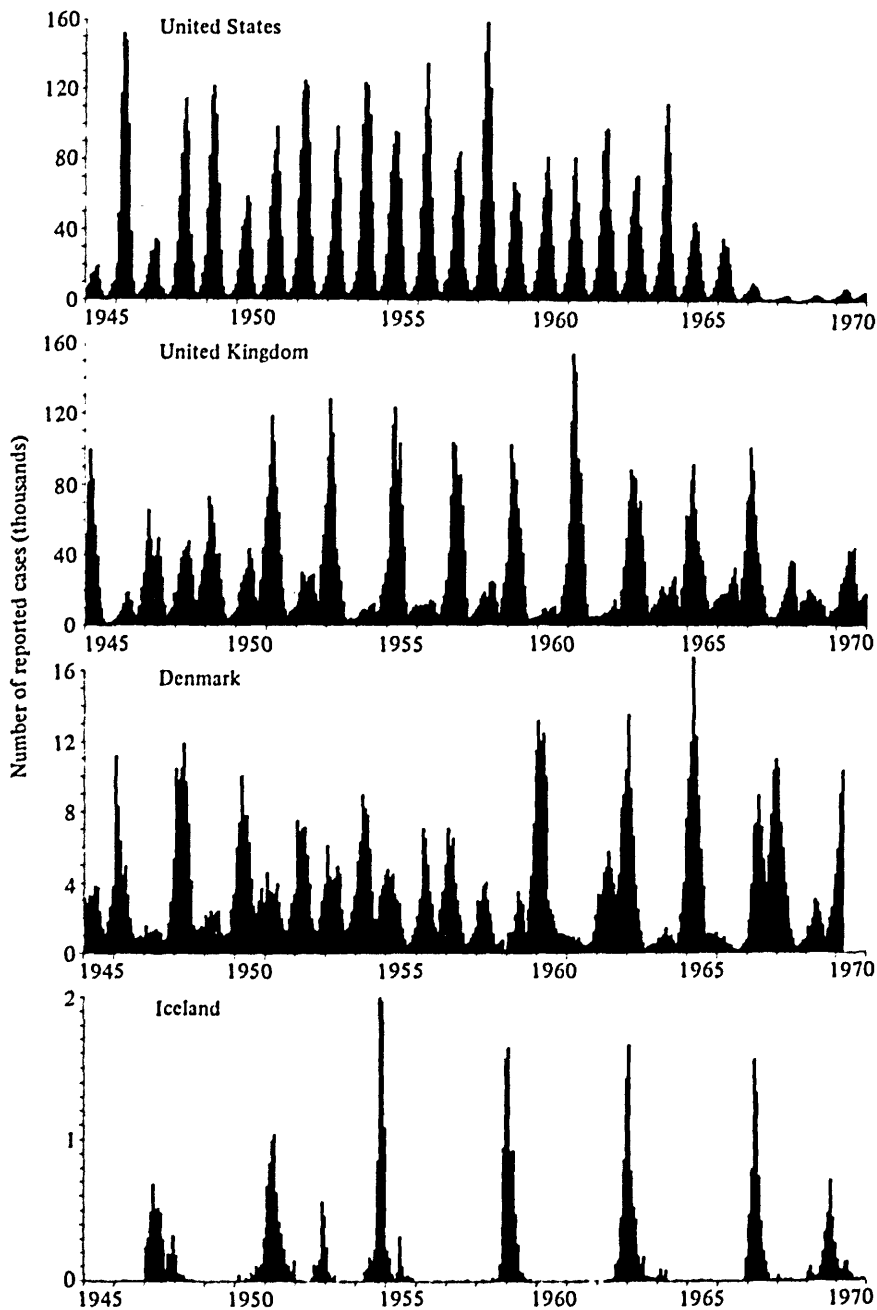


Fig. 4. Reported cases of measles, 1945-70, from United States, United Kingdom, Denmark and Iceland. Source: W.H.O. bulletins. Note the effect of organized vaccination programmes on the United States series since 1965.

creased. To an ever-increasing extent, the behaviour of Icelandic measles waves moved towards the regular patterns of Western Europe and eastern North America shown in Fig. 4. Internal isolation was reduced by the development of an extensive national airline network. This has helped to overcome the winter communication difficulties which affect road and boat travel.

The internal and external bonding of Iceland to other countries means, since measles is not endemic in Iceland, that seasonal patterns now tend to follow those of nations with most contacts with Iceland (particularly the United States, Denmark, the United Kingdom and Germany). The external links are the vehicle for the reintroduction of infection, while the internal links bring widespread dissemination. As a result, the post-war seasonal pattern shown in Fig. 1B is like that in many other northern countries. The shifting seasonal pattern in Iceland over this century and its interpretation in terms of communication changes indicates a close association between epidemiological phenomena and the increased mobility of infected cases.

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