# Health and the Urban Environment

## XIII. The Incidence and Burden of Minor Illness in a Healthy Population: Familial Spread[1-4]

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**SUMMARY**

Familial spread was measured longitudinally in a family population and compared to that in similar familial studies. Despite major differences in methods, the studies showed similar results. Major differences in attack rates were found by age of introducer, age of secondary case, and family composition. Although upper respiratory infections were ubiquitous, familial spread did not appear to be large.

The important determinants of familial spread in this study, as in other studies, appeared to be the age of the index case, severity of the illness, the number of other family members and their ages. Family size, by itself, was not a major determinant. For acute illnesses, the family remained the largest source of spread.

### Introduction

Familial spread of acute upper respiratory illnesses has been studied in various localities and by various methods. The families studied have yielded somewhat similar results when the studies overlapped in content, despite the varying methods and circumstances (1, 2). In addition, each study presented different information, from which it was possible to obtain a broad idea of the nature of the spread of acute illness within a family.

### Materials and Methods

The Cornell Family Illness Study and its methods have been described previously (3). Secondary attack rate was defined as the number of new cases of an illness in a family after introduction of the illness by the index case to the number of persons exposed that occurred within a specified time interval after onset of the index illness. Illness meant both specific illnesses and broad categories of acute illness. Index case re-

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ferred to the first case of a type of illness in the family at that time. Interval between illnesses was defined as the period between termination of last known illness and next onset of the same type of illness.

## Results

The secondary attack rates found in this study were generally similar to those reported in other studies (1, 2, 4) when the same interval between onset of the index illness and the secondary cases was used. The over-all rate within a 10-day interval was 20 per cent, and within a 15-day interval, it was 27 per cent (table 1).

When the secondary attack rate was examined by family size and by broad category of illness (table 2), a great deal of variation was found. Secondary attack rates were higher for the broad category of "common colds." The attack rate by family size is given in table 3.

One major determinant of the secondary attack rate was the family status of a subject, and another was the family composition in general (table 4). A method discussed by Badger (5) was used in this study. The mother was used as a standard against which other family members were compared in terms of susceptibility, communicability, and chance of introducing a new illness (table 4). The father was less susceptible, less communicable, and less likely to introduce new illness (table 4). He was similar in this respect to the children 15 or more years of age. The youngest children were most susceptible, most communicable, and most likely to introduce illness. In these respects, the mother was closer to the children than to either the older children or the father.

Introduction by the youngest children (table 5) was often followed by the highest secondary attack rate (4). In addition, introducers of each class of family members were good sources of infection for at least one class of exposed family members (6). Attack rates also differed by age, with the highest secondary attack rates appearing in the younger family members. When examined by age of introducer, age of secondary case, and type of illness, it was found that children less than 15 years of age always had greater rates of illness than the older members, regardless of who introduced the illness and the type of illness. The highest secondary attack rates occurred in the broad categories of illness with more symptoms as well as those of longer duration (i.e., severity). Generally, there was some age specificity, with children less than 15 years of age spreading the illnesses to other children of the same age group.

As Fox (6) has stated, "This suggests that spread relates chiefly to degree of contact (and, presumably, the immunity status of those exposed)." All of the family studies (1, 2, 4) agreed that the likelihood that a given class of family members would introduce illness was a function of immunity status and degree of exposure to extrahousehold as well as intrahousehold sources of

TABLE 1

SECONDARY ATTACK RATE BY CATEGORY OF ILLNESS FOR 3 TIME INTERVALS FOR ALL FAMILY SIZES

| | Five-Day Rate | | | Ten-Day Rate | | | Fifteen-Day Rate | | |
|---|---|---|---|---|---|---|---|---|---|
| Category | Secondary Cases (no.) | Exposed (no.) | Attack Rate (%) | Secondary Cases (no.) | Exposed (no.) | Attack Rate (%) | Secondary Cases (no.) | Exposed (no.) | Attack Rate (%) |
| Cold | 1,030 | 5,850 | 17.6 | 1,460 | 5,850 | 25.0 | 1,946 | 5,850 | 33.3 |
| Rhinitis | 118 | 995 | 11.8 | 164 | 995 | 16.5 | 203 | 995 | 20.4 |
| Cough/sore throat | 112 | 1,433 | 7.8 | 193 | 1,433 | 13.5 | 277 | 1,433 | 19.3 |
| Gastrointestinal | 257 | 2,264 | 11.4 | 382 | 2,264 | 16.9 | 522 | 2,264 | 23.0 |
| Other | 394 | 3,409 | 11.6 | 594 | 3,409 | 17.4 | 780 | 3,409 | 22.9 |
| Total | 1,911 | 13,951 | 13.7 | 2,793 | 13,951 | 20.0 | 3,725 | 13,951 | 26.7 |

TABLE 2

SECONDARY ATTACK RATE FOR 3 TIME INTERVALS BY SIZE OF FAMILY AND BROAD TYPE OF ILLNESS

| | 2 | | | 3 | | | 4 | | | 5 | | | 6 | | | 7 | | | 8 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2° | At Risk | Rate | 2° | At Risk | Rate | 2° | At Risk | Rate | 2° | At Risk | Rate | 2° | At Risk | Rate | 2° | At Risk | Rate | 2° | At Risk | Rate |
| Five-Day | | | | | | | | | | | | | | | | | | | | | |
| Cold | 32 | 209 | 15.31 | 117 | 532 | 21.99 | 240 | 1,257 | 19.09 | 244 | 1,268 | 19.24 | 188 | 1,060 | 17.73 | 73 | 618 | 11.81 | 136 | 896 | 15.18 |
| Rhinitis | 4 | 51 | 7.84 | 15 | 116 | 12.93 | 37 | 243 | 15.23 | 18 | 184 | 9.78 | 26 | 190 | 13.68 | 12 | 96 | 12.50 | 6 | 115 | 5.22 |
| Cough/sore throat | 12 | 60 | 20.00 | 12 | 154 | 7.79 | 28 | 279 | 10.04 | 26 | 276 | 9.42 | 20 | 240 | 8.33 | 8 | 120 | 6.67 | 16 | 304 | 5.26 |
| Gastrointestinal | 17 | 98 | 17.35 | 37 | 276 | 13.41 | 85 | 588 | 14.46 | 46 | 416 | 11.05 | 28 | 335 | 8.36 | 24 | 180 | 13.33 | 20 | 371 | 5.39 |
| Other | 37 | 202 | 18.32 | 61 | 342 | 17.84 | 96 | 774 | 12.40 | 74 | 672 | 11.01 | 51 | 450 | 11.33 | 20 | 294 | 6.80 | 55 | 675 | 8.15 |
| Ten-Day | | | | | | | | | | | | | | | | | | | | | |
| Cold | 45 | 209 | 21.53 | 165 | 532 | 31.02 | 362 | 1,257 | 28.80 | 332 | 1,268 | 26.18 | 277 | 1,060 | 26.13 | 108 | 618 | 17.47 | 171 | 896 | 19.08 |
| Rhinitis | 9 | 51 | 17.65 | 22 | 116 | 18.97 | 45 | 243 | 18.52 | 28 | 184 | 15.21 | 33 | 190 | 17.37 | 19 | 96 | 19.79 | 8 | 115 | 6.96 |
| Cough/sore throat | 16 | 60 | 26.67 | 21 | 154 | 13.64 | 46 | 279 | 16.49 | 37 | 276 | 11.59 | 34 | 240 | 14.17 | 12 | 120 | 10.00 | 27 | 304 | 8.88 |
| Gastrointestinal | 27 | 98 | 27.55 | 65 | 276 | 19.93 | 118 | 588 | 20.07 | 72 | 416 | 17.30 | 47 | 335 | 14.03 | 30 | 180 | 16.67 | 33 | 371 | 8.89 |
| Other | 47 | 202 | 23.27 | 88 | 342 | 25.73 | 154 | 774 | 19.90 | 112 | 672 | 16.67 | 74 | 450 | 16.44 | 35 | 294 | 11.90 | 84 | 675 | 12.44 |
| Fifteen-Day | | | | | | | | | | | | | | | | | | | | | |
| Cold | 65 | 209 | 31.10 | 209 | 532 | 39.29 | 492 | 1,257 | 39.14 | 442 | 1,268 | 34.85 | 360 | 1,060 | 33.96 | 135 | 618 | 21.84 | 243 | 896 | 27.12 |
| Rhinitis | 10 | 51 | 19.61 | 32 | 116 | 27.59 | 56 | 243 | 23.05 | 33 | 184 | 17.93 | 40 | 190 | 21.05 | 21 | 96 | 21.88 | 11 | 115 | 9.57 |
| Cough/sore throat | 20 | 60 | 33.33 | 33 | 154 | 21.43 | 67 | 279 | 24.01 | 48 | 276 | 17.39 | 50 | 240 | 20.83 | 21 | 120 | 17.50 | 38 | 304 | 12.50 |
| Gastrointestinal | 34 | 98 | 34.69 | 75 | 276 | 27.17 | 161 | 588 | 27.38 | 103 | 416 | 24.75 | 80 | 335 | 17.91 | 39 | 180 | 21.67 | 80 | 371 | 13.48 |
| Other | 61 | 202 | 30.20 | 115 | 342 | 33.63 | 211 | 774 | 27.26 | 147 | 672 | 21.87 | 93 | 450 | 20.66 | 42 | 294 | 14.29 | 111 | 675 | 16.44 |

infection, and that this likelihood was greater for children than for adults.

Approximately 50 per cent of the secondary cases of an illness and of "common cold" occurred within 5 days, and 75 per cent, within 10 days (table 6). Approximately one half of all "common cold" illnesses were secondary cases, occurring within 15 days of the onset of the index case. Colds were missed in families if the time interval between primary and secondary cases was too small.

## Discussion

Despite the major differences among the studies reviewed (1, 2, 4), the results appeared to be similar. Some differences were found when family composition was examined. Compared to the 20 per cent attack rate in 10 days reported herein, Fox and associates (6) reported a 32 per cent secondary attack rate for rhinovirus-associated illnesses whereas Brimblecombe and co-workers (1) reported a rate of 15.5 per cent within 9 days, and Buck (7) reported a rate of 17.8 per cent within 7 days. These differences are small.

In comparing the secondary attack rates with the results of Lidwell and Williams (2), Brimblecombe and co-workers (1), and Dingle and associates (4), all of whom used different intervals, the over-all results were similar. The effect of family composition on secondary attack rates was very strong in all studies. Andrewes (8) and Fox and associates (6) suggested that some persons may be more effective spreaders of infection than others. Lidwell and Sommerville (9) found that among rural British families the school-age child was the most effective spreader of illness, with a secondary attack rate of 19.2 per cent. Examining the risk of cross infection, Brimblecombe and co-workers (1) found that younger children were much more susceptible than the older children, and both groups were more susceptible than the adults. They also found that the first case generally appeared in the most susceptible person.

The highest attack rates in the other studies were also found among the youngest subjects. Dingle and associates (4) reported 45 per cent, Lidwell and Sommerville (9) reported 54 per cent, and Fox and co-workers (6) reported 56 per cent for preschool children. The findings by category of illness and age were in close agreement with those of Buck (7).

A comparison with other studies (table 6) showed only minor differences in the proportion of secondary cases within stated in-

TABLE 3

SECONDARY ATTACK RATE* IN PER CENT FOR COLDS, BY FAMILY SIZE

| Source of Data | All Families (%) | Family Size 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| This study | 24 | 21 | 29 | 27 | 25 | 25 | 18 | 18 |
| Dingle et al (4) | 25 | — | 26 | 26 | 25 | 26 | 24 | 25 |

*Within 10 days of onset of index case.

tervals of the onset of the index case in a family, except that the rates reported by Dingle and associates (4) appeared to be smaller than those of other observers (1–3). These results were for upper respiratory infections regardless of specific agent.

One major obstacle in the present study of familial spread was that relatively little was known about the agents that were responsible. Even in virus studies such as those by Andrewes (8) and Fox and associates (6), isolation rates were still too low to be more than simple indicators. When more is known about the agents, differences will cer-

TABLE 4

ESTIMATED CROSS INFECTION RATES OF ACUTE CORYZA/COLD WITHIN 9 DAYS OF PRIMARY CASE, FOR FAMILY SIZE 5 DATA FROM BRIMBLECOMBE AND ASSOCIATES AND CORNELL FAMILY ILLNESS STUDY

| Index Case | Secondary Attack Rate in % Exposed: Father | Mother | Oldest Child | Middle Child | Youngest Child |
|---|---|---|---|---|---|
| Brimblecombe et al* | | | | | |
| Father | — | 14 | 6 | 8 | 17 |
| Mother | 7 | — | 9 | 9 | 11 |
| Oldest child | 8 | 8 | — | 15 | 20 |
| Middle child | 5 | 9 | 16 | — | 21 |
| Youngest child | 7 | 4 | 11 | 13 | — |

| | Father | Mother | Child, 15 + Years | Child, 5–14 Years | Child, ⩽4 Years |
|---|---|---|---|---|---|
| CFIS† | | | | | |
| Father | — | 10 | 3 | 14 | 17 |
| Mother | 7 | — | 10 | 39 | 33 |
| Child, 15 + years | 1 | 3 | — | 8 | 1 |
| Child, 5–14 years | 6 | 26 | 6 | — | 35 |
| Child, ⩽4 years | 11 | 21 | 19 | 22 | — |

| | Family Status and Introduction and Spread of Infection: Relative Susceptibility Ratio | Relative Communicability Ratio | Apparent Introduction Ratio | Adjusted Introduction Ratio | Introduction Rate** |
|---|---|---|---|---|---|
| CFIS | | | | | |
| Father | 0.36 | 0.41 | 0.56 | 1.56 | 1.46 |
| Mother | 1.00 | 1.00 | 1.00 | 1.00 | 2.62 |
| Child, 15 + years | 0.49 | 0.13 | 0.82 | 1.67 | 2.15 |
| Child, 5–14 years | 1.29 | 0.94 | 1.28 | 0.99 | 3.35 |
| Child, ⩽4 years | 1.36 | 0.93 | 1.87 | 1.38 | 4.89 |

*Reference 1.

†CFIS = Cornell Family Illness Study; this study.

**All people approximate.

TABLE 5

INTRODUCTIONS AND SECONDARY CASES WITHIN 7 DAYS OF INDEX CASE,* BY TYPE OF ILLNESS AND AGE

| Illness | Introductions: Age (years) | Introductions: (no.) | Secondary Cases in Those Exposed: <15 Years (no.) | <15 Years (ratio)† | >15 Years (no.) | >15 Years (ratio) |
|---|---|---|---|---|---|---|
| "Common cold," alone or with rhinitis | <15 | 247 | 82 | 33.2 | 23 | 9.3 |
| | >15 | 196 | 34 | 17.3 | 18 | 9.2 |
| "Colds," with rhinitis and cough and/or sore throat | <15 | 380 | 191 | 50.3 | 56 | 14.7 |
| | >15 | 321 | 53 | 16.5 | 41 | 12.8 |
| "Colds," with other combinations of symptoms | <15 | 195 | 25 | 12.8 | 30 | 15.4 |
| | >15 | 270 | 33 | 12.2 | 35 | 13.0 |
| Non-"cold" illnesses | <15 | 250 | 48 | 19.2 | 26 | 10.4 |
| | >15 | 305 | 34 | 11.1 | 43 | 14.1 |

*Including multiple introductions.
†Ratio of secondary cases to introductions x 100.

tainly be found among agents as far as secondary attack rates in both levels and differentials are concerned.

The burden and incidence of minor illness in a healthy urban population found by the Cornell Family Illness Study has been presented in 3 reports. Four major conclusions can be drawn. (*1*) The amount and duration of illness in a "healthy" population was extraordinary: approximately 90 per cent of the population was ill more than 25 per cent of the time. (*2*) The overwhelming preponderance of illness consisted of upper respiratory syndromes. (*3*) Reported (perhaps perceived would be a better word) minor illness was inversely related to socioeconomic status and largely independent of family size. (*4*) Young children most commonly introduced illness, were most infectious, most susceptible, and accounted for the greatest burden of symptoms.

The Cornell Family Illness Study has documented, more fully than others, the extent of the burden of illness sustained by normal urban populations. In other respects, the results of this study were remarkably similar to those of other investigations of minor family illness, and the similarity of the findings despite differences in populations, methods, and criteria of illness validates the results.

To the investigator, this should be reassuring; however, the studies reviewed here, have spanned at least a quarter of a century. The same 25 years have seen major changes in medical care, a revolution in ef-

TABLE 6

DISTRIBUTION OF INTERVALS BETWEEN THE COLDS OF FAMILY MEMBERS AS PER CENT OF TOTAL COLDS

| Interval (days) | Cornell Family Illness Study (no.) | Cornell Family Illness Study (%) | Lidwell and Williams (2) (no.) | Lidwell and Williams (2) (%) | Brimblecombe et al (1) (no.) | Brimblecombe et al (1) (%) | Dingle et al (4) (no.) | Dingle et al (4) (%) |
|---|---|---|---|---|---|---|---|---|
| 5 | 1,030 | 26 | 308 | 34 | | | | |
| 9 | — | — | 372 | 41 | 483 | 32 | | |
| 10 | 1,460 | 37 | 386 | 42.6 | | | 4,738 | 32 |
| 15 | 1,946 | 49 | 436 | 48.1 | | | 4,909 | 33 |
| Total no. colds | 3,971 | 100 | 907 | 100 | 1,510 | 100 | 14,990 | 100 |

fective chemotherapy, and the rise of unprecedented affluence.

These changes parallel the sanitary revolution of the last century, in which the nature of prevalent disease changed profoundly and rapidly. Despite this, the large majority of the population continues to be weighed down by an ongoing symptom load. The burden is largely private and not expressed in days lost from usual public activity.

The reasons why this illness load has not diminished are several. The agents presumed to be causal are not responsive to present chemotherapy or immunizations. The immunity conferred by infection is of low level and short duration. The mode of transmission is not interrupted by conventional sanitary control (e.g., water treatment). No evidence has been produced to suggest that transmission or infection could not be interrupted.

It is suspected that the problem is one of the perception of illness. Despite a reduction in function in the afflicted, these illnesses are not seen as a threat to health. Once reassured that his minor respiratory illness will not progress to serious disease, the person accepts it as a necessary fact of life.

The tremendous burden of illness, however, remains an endemic problem of considerable proportion. The results of this study suggest that future research should be expanded into such other areas as the influence of minor acute respiratory illness on chronic lung disease. Further, the constancy of the findings in this and previous studies also indicates the usefulness of these syndromes in studies of illness perception and as biologic indicators of environmental effects.

*RESUMEN*

La salud y el medio ambiente urbano. XIII. Incidencia y molestias de enfermedades menores en una población sana: Propagación familial

La propagación familial fué medida longitudinalmente en una población de familias y comparada con aquella en estudios familiales similares. A pesar de las diferencias mayores en los métodis usados, los estudios mostraron resultados similares. Las diferencias mayores en la proporción de ataques fueron encontradas en la edad del introductor, la edad del caso secundario, y la composición de la familia. Aunque las infecciones respiratorias superiores fueron ubicuas, la propagación familial no pareció mayor.

Los determinantes importantes en la propagación familial en este estudio, así como en otros estudios, pareció ser la edad del caso índice, la gravedad de la enfermedad, el número de miembros en la familia, y sus edades. El tamaño de la familia en sí no fué un determinante mayor. En la enfermedad aguda, la familia permaneció como la fuente mayor de propagación.

*RESUME*

Environnement urbain et santé. XIII. Incidence et importance des affections mineures dans une population saine. Transmission familiale

La transmission familiale a été mesurée longitudinalement dans un ensemble de familles, et comparée à celle qui avait été observée dans des études familiales similaires, malgré des différences majeures dans les méthodes utilisées. Ces études montrent des résultats analogues. Des différences importantes dans les taux d'attaque ont été observées d'après l'âge du cas responsable de l'introduction de la maladie, l'âge du cas secondaire, et la composition familiale. Quoique les infections respiratoires supérieures se rancontrent partout, la transmission familiale n'a pas semblé être notable.

Les facteurs importants qui interviennent dans la transmission familiale, tels qu'ils sont apparus dans cette étude, de même que dans d'autres études, se révèlent être l'âge du cas indice, la gravité de la maladie, le nombre d'autres personnes dans la famille, et l'âge de celles-ci. La dimension de la famille, en elle-même, n'a pas constitué un facteur capital. En ce qui concerne les affections aiguës, la famille est demeurée la source la plus importante de la transmission.

## References

1. Brimblecombe, F. S. W., Cruickshank, R., Masters, P. L., Reid, D. D., Stewart, G. T., and Sanderson, D.: Family studies of respiratory infections, Brit. Med. J., 1958, *1*, 119.
2. Lidwell, O. M., and Williams, R. E. O.: The

epidemiology of the common cold. II. Cross-infections and immunity, J. Hyg. (Camb.), 1961, *59*, 321.

3. Lebowitz, M., Cassell, E. J., and McCarroll, J.: The incidence and burden of minor illness in a healthy population. XI. Methods, symptoms, and incidence, Amer. Rev. Resp. Dis., 1972, *106*, 824.
4. Dingle, J. H., Badger, G. F., and Jordan, W. S.: Illness in the Home, Western Reserve University Press, Cleveland, 1964.
5. Badger, G. F., Dingle, J. H., Feller, A. E., Hodges, R. G., Jordan, W. S., Jr., and Rammelkamp, C. H., Jr.: A study of illness in a group of Cleveland families. II. Incidence of the common respiratory diseases, Amer. J. Hyg., 1953, *58*, 31.
6. Fox, J. P., Elveback, L. R., Spigland, I., Frothingham, T. E., Stevens, D. A., and Huger, M.: The virus watch program: A continuing surveillance of viral infections in metropolitan New York families: I. Overall plan, methods of collecting and handling information and a summary report of specimens collected and illnesses observed, Amer. J. Epidem., 1966, *83*, 389.
7. Buck, C.: Acute upper respiratory infections in families, Amer. J. Hyg., 1956, *63*, 1.
8. Andrewes, C. H.: The complex epidemiology of respiratory virus infections, Science, 1964, *146*, 1274.
9. Lidwell, O. M., and Sommerville, T.: Observations on the incidence and distribution of the common cold in a rural community during 1948 and 1949, J. Hyg. (Camb.), 1951, *49*, 365.