Factors of importance for changes in dental caries among adults

A follow-up study of Oslo citizens from the age of 35 to 50 years

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Eighty-one 35-year-old Oslo citizens examined in 1973 were reexamined after 15 years, to monitor changes in their caries situation expressed as carious surfaces (DS + D_FS). Factors considered to be of importance for a change in the number of carious surfaces over this 15-year period were arranged under four items: environment, behavior, human biology, and health care organization. The results showed a slight but not statistically significant increase in the overall caries experience expressed as DMFS. A statistically significant reduction in DS + D_FS from the age of 35 to 50 years was demonstrated. Despite this reduction 23% of the 50-year-olds had more carious surfaces than at age 35. The results indicate that the improvement in the number of untreated carious surfaces reported from many Western societies is also valid for adult Norwegians. However, this improvement is not shared by all. Multivariate analyses showed that behavioral factors had the greatest impact on the observed changes in dental health. □ *Adults; dental caries; epidemiology; health behavior*

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Results from cross-sectional investigations indicate the oral health status in society, whereas consecutive cross-sectional studies may be utilized to demonstrate trends with regard to changes in the level of oral health on a group basis. However, follow-up studies of the same individuals offer the best possibilities for disclosing and analyzing changes in oral health status. A follow-up study may identify individuals with different levels of changes.

On the basis of cross-sectional studies in Western societies, a reduction of more than 50% in the number of carious surfaces has been documented during the past 15 years (1–3). Despite this overall caries reduction, however, these studies have also shown that there are still individuals within these populations with a high number of carious surfaces.

The etiology of dental caries has been extensively investigated, and the dynamics of caries development and progression has been established on the basis of in vitro and in vivo studies in animals and man. In conclusion, the prerequisites for caries development are defined to be a susceptible host, sugar, and acidogenic microorganisms colonizing the tooth surface (4–6). However, it has also been increasingly evident that dental caries may be considered a multifactorial disease with both social and behavioral characteristics in addition to the biologic determinants (7–14).

The aims of the present study were to a) contrast the caries experience in a random sample of 35-year-old Oslo citizens investigated in 1973 (15) and reexamined 15 years later; b) describe any observed changes; c) identify individuals with a stable or improved caries situation and compare them with individuals with an increased number of decayed surfaces (DS + D_FS) from the first to the second examination; and d) to characterize these two groups of individuals by means of a multifactorial approach, including environ-

mental, behavioral, biologic, and health care organization variables in a socioecologic model (Fig. 1) (11, 13). The dependent variable, the number of dental caries lesions ($DS + D_FS$), which includes decayed surfaces previously filled and decayed surfaces previously not filled, was dichotomized as being the same, lower numbers, or higher numbers at the age of 50 compared with the situation recorded at age 35 years.

Materials and methods

A random sample of 116 35-year-old Oslo citizens examined in 1973 (15) were invited to participate in a follow-up examination in 1988. Seventeen persons had moved from the Oslo region, and four had died during the 15 years. The final sample size, after exclusion of dropouts, was reduced to 81 persons—that is, 85% attendance. Those not responding after a mail reminder and an invitation by telephone were asked to answer a questionnaire about the number of remaining teeth, their dental habits, several psychosocial factors, and the reasons for not attending the examination. In the follow-up study the clinical examination was performed by one examiner (E. Bjertness) who was thoroughly calibrated with the investigator in 1973 (B. F. Hansen), and the methods applied in 1973 and 1988 were identical.

Decayed surfaces were recorded clinically when a softened floor or wall of a cavity could be registered by probing (1, 16) and radiographically in accordance with Hollender & Koch (1, 17). Third molars were included. Bitewing radiographs of the posterior dentition were obtained from all subjects except two in whom teeth in the lateral segments were missing.

In addition to the clinical and radiographic examination, saliva samples from all participants in 1988 were analyzed with regard to stimulated secretion rate, buffer capacity, and the number of *Streptococcus mutans* colony-forming units (1, 11, 13). Questionnaires about psychosocial factors and dental health habits were also collected.

The independent variables used were organized in accordance with the health field concept (18) and adapted to dental conditions through the socioecologic caries model (11, 13). These variables and their operationalization are shown in Table 3. For further details, see previous studies (11, 13, 19).

Regular intraexaminer calibration tests were performed before and during the examination period. The initial calibration period was terminated when it reached 90% consistency.

Statistical methods

Analysis of variance (*F*-test) was used for statistical evalulation of the bivariate relationships between each independent and the dependent variable and for comparison of DMFS values from 1988 and 1973. Multiple classification analysis (MCA) was the multivariate method chosen in the present study. A comprehensive discussion of the MCA is presented in previous papers (11, 13).

The level of significance was set to $p = 0.01$ owing to the hypothesis-generating nature of the study and the high number of statistical tests performed.

Results

There was a tendency towards a higher caries experience (DMFS) and higher number of missing (MS) and filled (FS) surfaces at the age of 50 than at 35 years, but the differences were not statistically significant (Table 1). With the regard to the mean number of carious surfaces ($DS + D_FS$) a statistically significant reduction from 6.7 carious surfaces to 3.5 during the 15-year interval was registered (Table 1).

Of the 81 persons investigated, 62 (77%) showed an improved or stable caries situation expressed as $DS + D_FS$, whereas 19

Fig. 1. A socioecologic model indicating the four main items with subgroups yielding a pressure towards stable/improved versus deteriorated dental health. Centrally, the distribution of carious surfaces detected at 35 years of age (----) and at 50 years of age (———).

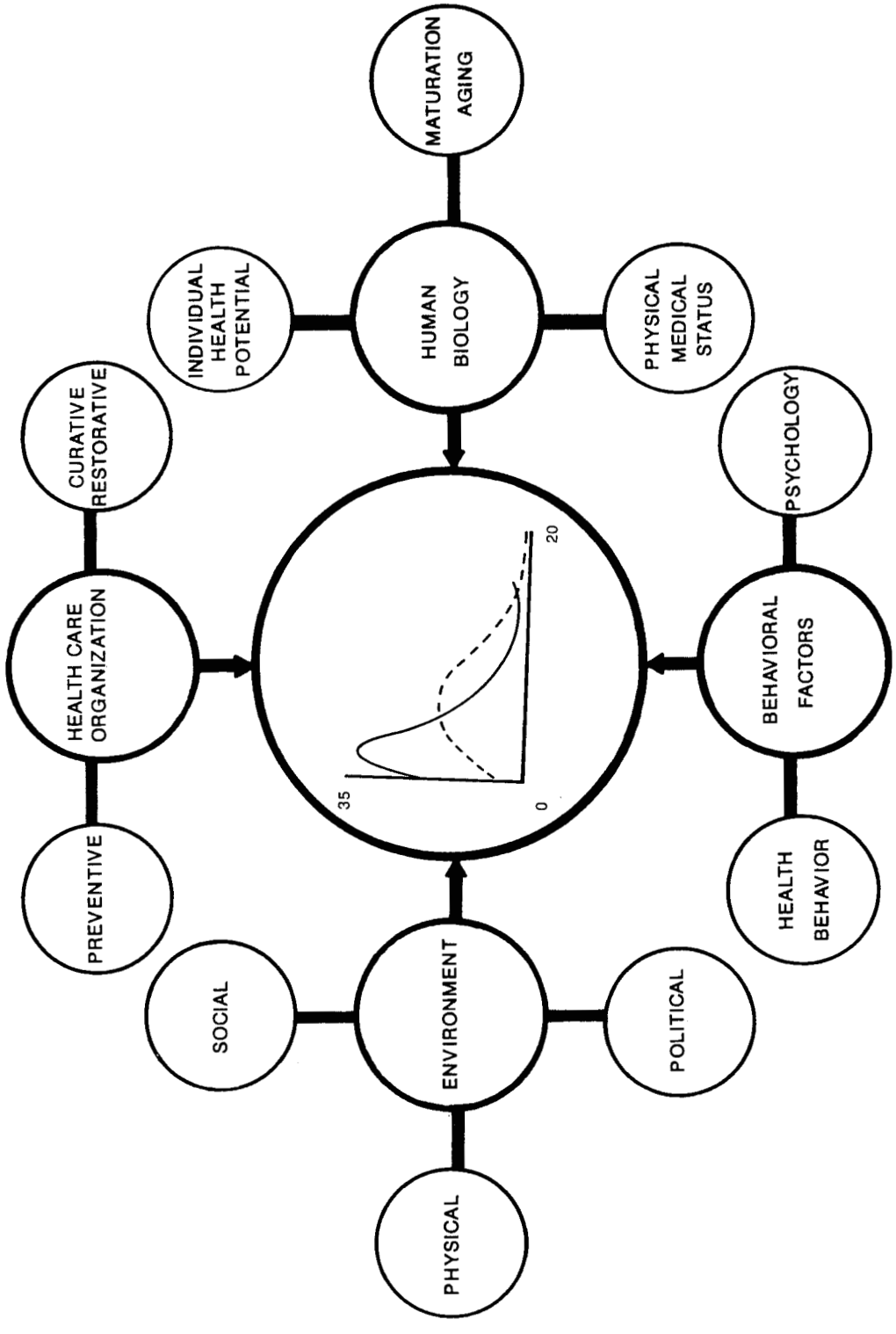
MATURATION AGING
INDIVIDUAL HEALTH POTENTIAL
HUMAN BIOLOGY
PHYSICAL MEDICAL STATUS
CURATIVE RESTORATIVE
PSYCHOLOGY
HEALTH CARE ORGANIZATION
BEHAVIORAL FACTORS
PREVENTIVE
HEALTH BEHAVIOR
SOCIAL
ENVIRONMENT
POLITICAL
PHYSICAL
35
0
20

Table 1. Comparison of D, M, and F values on the basis of surfaces (S) at age 35 and 50 years in 1973 and 1988, respectively

	35 years old (1973)		50 years old (1988)		
	n = 81	SD	n = 81	SD	p
Caries experience (DMFS)	84.0	17.3	90.3	17.4	NS
Decayed surfaces (DS + D_FS)	6.7	4.8	3.5	3.9	*
Missing surfaces (MS)	27.2	17.7	30.2	18.2	NS
Filled surfaces (FS)	54.2	16.5	59.3	17.5	NS

Statistical significance, * $p < 0.01$; NS = not significant.

(23%) showed a worsened situation. The mean number of carious surfaces among those in the stable/improved group was 7.6 at the age of 35 years and 2.3 at age 50 (Table 2). The corresponding figures among the 19 with increased caries were 3.7 and 7.6, respectively.

Subjects with the same number of or fewer carious surfaces (DS + D_FD) in 1988 as compared with 1973 were assigned a score of 1, whereas subjects with a greater number of carious surfaces in 1988 were given a score of 2. The 'mean scores' in Table 3 reflect the mean of these scores and are correlated bivariately with each independent variable included.

A statistically significant difference between subjects with either the same/fewer or more carious surfaces was found for some of the independent behavioral variables (alcohol problems, psychologic status, and address changes during the past 15 years) (Table 3). In multivariate analysis the behavioral variables together explained 26% ($R^2 = 0.256$) of the variation in the dependent variable (Table 4), whereas the explanatory powers of the environmental, human biology, and health care organization variables were negligible (not shown). When the independent variables with highest beta value from each of the four main items together (Fig. 1) (that is, those explaining most of the variance in the dependent variable in each of the four items) were selected and tested, 18% of the variation of the dependent variables was explained (R^2 = 0.181) (Table 5).

Discussion

The attendance (85%) was considered high when compared with cross-sectional studies (1, 19). More persons with low education

Table 2. The mean number of carious surfaces (DS + D_FS) for the groups with stable/improved versus deteriorated dental health at the age of 35 and 50 years in 1973 and 1988, respectively

	Stable/improved		Deteriorated		
	n = 62	SD	n = 19	SD	p
Mean no. of carious surfaces 1973, 35 years old	7.6	4.8	3.7	3.4	*
Mean no. of carious surfaces 1988, 50 years old	2.3	2.6	7.6	4.6	*
Comparison of mean caries in 1973 versus 1988	*		*		

Statistical significance, * $p < 0.01$.

Table 3. A bivariate analysis of the independent variables used in the present study with operationalization, distribution of individuals, mean and standard deviation of the dependent variable: stable/improved (score 1) versus deteriorated (score 2) dental health from the age of 35 to 50 years expressed as number of carious surfaces (DS + D_FS)

		Mean		
	n	Score	SD	Probability (*p*)
Environment				
Years at school				
≤10	26	1.27	0.452	0.618^{NS}
>10	55	1.22	0.417	
Social class				
Class 1	11	1.46	0.522	
Class 2	52	1.19	0.398	0.179^{NS}
Class 3	18	1.22	0.428	
Economy				
Unsatisfied	7	1.14	0.378	0.555^{NS}
Satisfied	74	1.24	0.432	
Divorce last 15 years				
0	65	1.19	0.391	0.033^{NS}
≥ 1	16	1.44	0.512	
Behavioral factors				
Nutritional status (main meals)				
0–2	24	1.29	0.464	0.438^{NS}
>2	57	1.21	0.411	
Alcohol				
No alc. probl.	78	1.21	0.406	0.001*
Alc. problems	3	2.00	0.000	
Exercise				
No	42	1.29	0.457	0.265^{NS}
Yes	39	1.18	0.389	
Smoking				
No	52	1.15	0.364	0.022^{NS}
Yes	29	1.38	0.494	
Psychologic status				
Satisfied	72	1.18	0.387	0.001*
Unsatisfied	9	1.67	0.500	
Sugar between meals				
<Daily	64	1.23	0.427	0.994^{NS}
≥Daily	17	1.24	0.437	
Tooth cleaning				
Good	25	1.08	0.277	
Medium	40	1.30	0.464	0.091^{NS}
Bad	16	1.31	0.479	
Brushing				
Once/day	19	1.32	0.465	0.346^{NS}
>Once/day	62	1.20	0.407	
Interdental cleaning				
No	24	1.17	0.381	0.356^{NS}
Yes	57	1.26	0.444	
Use of fluoride				
No	5	1.60	0.548	0.047^{NS}
Yes	76	1.21	0.410	
Address changes last 15 years				
0–1	55	1.15	0.356	0.005*
>1	26	1.42	0.504	

(Continued next page)

Table 3. *(Continued)*

		Mean		
	n	Score	SD	Probability (*p*)
Human biology				
Sex				
Woman	36	1.19	0.401	0.452^{NS}
Man	45	1.27	0.447	
Physical fitness				
Unsatisfied	10	1.20	0.422	0.786^{NS}
Satisfied	71	1.24	0.430	
Weight status				
Unsatisfied	21	1.24	0.436	0.965^{NS}
Satisfied	60	1.23	0.427	
Allergy				
No	63	1.24	0.429	0.890^{NS}
Yes	18	1.22	0.428	
Streptococcus mutans				
≤ 20 colonies	33	1.30	0.467	0.254^{NS}
> 20 colonies	47	1.19	0.398	
Buffer capacity (pH)				
>4.0	46	1.22	0.417	0.628^{NS}
≤4.0	34	1.27	0.448	
Missing teeth				
≤5	52	1.21	0.412	0.518^{NS}
>5	29	1.28	0.455	
Saliva secretion (ml/min)				
≥1.0	45	1.29	0.458	0.202^{NS}
<1.0	36	1.17	0.378	
Chronic disease				
No	63	1.25	0.439	0.447^{NS}
Yes	18	1.17	0.383	
Medication				
No	59	1.22	0.418	0.626^{NS}
Yes	22	1.27	0.456	
Health care organization				
Regular dental visit (today)				
No	4	1.25	0.500	0.941^{NS}
Yes	77	1.23	0.426	
Regular dental visits (age 15 to 25 years)				
No	26	1.23	0.430	0.956^{NS}
Yes	55	1.24	0.429	
School dental care				
No	17	1.12	0.332	0.205^{NS}
Yes	64	1.27	0.445	
Recall system				
No	15	1.27	0.458	0.749^{NS}
Yes	66	1.23	0.422	

than with high education were lost in the recall study. This situation, also demonstrated in other longitudinal studies (20), may have influenced the results, and conclusions about changes in dental health variables (DMFS) (Table 1) must therefore be drawn with care. The study population may have a somewhat better dental health than the normal population. The socioecologic model may, however, not be influenced if we consider the model as a *process* that is not sample-dependent (21). The reliability

Table 4. Multiple classification analysis of the independent variables related to 'behavioral factors'. Twenty-six per cent of the total variation in the dependent variable stable/improved versus deteriorated dental health was explained by behavioral factors

	Eta	Beta
Psychologic status	0.361*	0.340*
Use of fluorides	0.221*	0.282*
Tooth cleaning	0.244*	0.263*
Address changes last 15 years	0.306*	0.151^{NS}
Smoking	0.255*	0.069^{NS}

$R^2 = 0.256$. Statistical significance * $p < 0.01$; NS = not significant.

of the caries measurement procedures was discussed in previous papers (11) and considered satisfactory.

The design of the DMF index is hierarchic and therefore not very sensitive to changes in populations with initially high DMF values. Changes in DS + D_FS were therefore considered more relevant for expressing an altered dental caries situation. The number of decayed surfaces (DS + D_FS) showed a statistically significant decrease over the 15-year period, but there was no statistically significant increase in DMFS, which may reflect the low sensitivity of the DMF index (Table 1). The reduction in decayed surfaces may represent an altered treatment philosophy among the dentists, but this may also confirm the improvement of dental health reported in many Western societies (1–3, 22–24). However, the fact that 23% of the sample had experienced deterioration in their dental health during this 15-year interval (Table 3) indicates that follow-up studies are of importance when describing changes in the caries situation in a population, because mean values from consecutive cross-sectional studies may mask important differences in a disease pattern in society.

Table 5. Multiple classification analysis of the independent variables selected to represent the main factors included in the socioecologic model. Eighteen per cent of the variation in the dependent variable stable/improved versus deteriorated dental health can be explained by these independent variables

	Eta	Beta
Psychologic status	0.361*	0.369*
Divorce last 15 years	0.238*	0.218*
Saliva secretion rate	0.143^{NS}	0.156^{NS}
School dental care	0.142^{NS}	0.100^{NS}

$R^2 = 0.181$. Statistical significance * $p < 0.01$; NS = not significant.

The socioecologic model was first established to explain the *variation* in the number of carious surfaces by means of a cross-sectional design (11, 13). The independent variables included in the present longitudinal study (Table 3) are based on the results obtained from testing the original socioecologic model in another group of 50-year-olds with regard to variation in dental health (11, 13). The present longitudinal design is an attempt to explain *changes* in dental health, and the study is inductive and hypothesis-generating by means of disclosing predictors for changes in dental health over time.

The behavioral factors were the most important variables with regard to changes in dental caries (Table 4). Psychologic status was the single most important variable, which was shown in previous studies to reflect the participants' situation at least during the last 5 years (25). All participants except four had visited the dentist every year the last 3 years, so the results should not be influenced by visiting habits. Furthermore, none of the health care organization factors was of importance bivariately (Table 1) or multivariately.

The effect of psychologic status did not change (beta = eta) when controlling for other independent behavioral variables (use of fluorides, tooth cleaning, address changes last 15 years, smoking) (Table 4) and human biology, environmental, and health care organization variables (Table 5). This indicates that the effect of psychologic status on changes in dental caries is independent of the other variables included. The mechanism is, however, unknown.

It is important to note that use of fluorides and tooth cleaning are two independent factors of importance for maintaining dental health (Table 4) and that changes in dental health, as measured in the present study, are not affected by educational level or social class.

The explained variance of 18% (Table 5) with regard to the total socioecologic model indicates that we have not disclosed all variables of importance for *changes* in dental caries, but behavioral variables should be considered important predictors. This is in accordance with the conclusions from multivariate studies on *variation* in dental health (11, 13).

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References

1. Bjertness E, Eriksen HM, Hansen BF. Caries prevalance of 35-year-old Oslo citizens in 1973 and 1984. Community Dent Oral Epidemiol 1986;14:277–82.
2. Downer MC. Changing patterns of disease in the Western World. In: Guggenheim B, editor. Cariology today. Basel: Karger, 1983:1–12.
3. Graves RC, Stamm JW. Oral health status in the United States: prevalence of dental caries. J Dent Educ 1985;49:341–51.
4. Keyes PH. Recent advances in dental caries research: bacteriological findings and clinical implication. Int Dent J 1962;12:443–64.
5. Krasse B. Caries risk. A practical guide for assessment and control. London: Quintessence, 1985.
6. Vanderas AP. Bacteriologic and nonbacteriologic criteria for identifying individuals at high risk of developing dental caries. A review. J Publ Health Dent 1986;46:106–13.
7. Jenny J, Frazier PJ, Bagramian RA, Proshek JM. Explaining variability in caries experience using an ecological model. J Dent Res 1974;53:554–64.
8. Beck JD, Kohout F, Hunt RJ. Identification of high risk adults: attitudes, social factors and diseases. Int Dent J 1988;38:231–8.
9. Abernathy JR, Graves RC, Bohannan HM, Stamm JW, Greenberg BG, Disney JA. Development and application of a prediction model for dental caries. Community Dent Oral Epidemiol 1987;15:24–8.
10. Hunter PB. Risk factors in dental caries. Int Dent J 1988;38:211–7.
11. Bjertness E. A multidimensional study of dental health in urban Norwegian adults [thesis]. Oslo, Norway: University of Oslo, 1990.
12. Demers M, Brodeur J-M, Simard PL, Mouton C, Veilleux G, Frechette S. Caries predictors suitable for mass-screenings in children: a literature review. Community Dent Health 1990;7:11–21.
13. Bjertness E, Eriksen HM. Design of a socio-ecologic caries model and testing on 50-year-old Oslo citizens. Acta Odontol Scand 1992;50:151–62.
14. Holst D. Levekår og tannhelse i Finnmark. Oslo, Norway: Institutt for samfunnsodontologi, University of Oslo, 1988.
15. Hansen BF. Dental conditions in a 35-year-old Norwegian urban population [thesis]. Oslo, Norway: University of Oslo, 1976.
16. Klein H, Palmer CE. Studies on dental caries. I. Dental status and dental needs of elementary school children. Public Health Rep 1938;5–3:751–65.
17. Hollender L, Koch G. Roentgenographic partial recording of caries in assessment of effect of prophylactic measures. Odontol Rev 1969;20:267–82.
18. Dever GEA. Epidemiology; focus on prevention. In: Dever GEA, editor. Epidemiology in health care management. Germantown, Md., USA: Aspen Publication, 1984:1–24.
19. Hansen BF. Caries experience in a Norwegian urban population. Community Dent Oral Epidemiol 1977;5:132–5.
20. Schumann H, Presser S. Questions and answers in attitude surveys. (Experiments on question form, working and content.) New York: Academic Press, 1981.
21. Aaberge R, Laake P. Om statistiske teorier for tolkning av data. Tidsskr Samfunnsforsk 1984;25: 165–86.
22. vd Fehr FR. Evidence of decreasing caries prevalence in Norway. J Dent Res 1982;61(spec issue): 1331–5.
23. Marthaler TM. Caries status in Europe and predictions for future trends. ORCA Satellite Symposium, Yugoslavia, 1990. Caries Res 1990;24: 381–96.
24. Koch G. Evidence of decreasing caries prevalence in Sweden. J Dent Res 1982;61(spec issue):1340–5.
25. Cantril H. In: Cantrill H, editor. The pattern of human concerns. New Brunswick, N.J., USA: Rutgers University Press, 1965:33–66.

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