empyema showed, in this survey, a high incidence of diphtheria. From these facts one must conclude that, as has already been shown by others, a man from a rural community is not as great an asset to his organization in the early part of his military career as is an urban individual.

CONCLUSIONS

1. A single negative culture is only of relative value, as is shown by the fact that preoperative cultures, taken from tonsils that later proved positive for diphtheria, were negative in 22.8 per cent. of the cases.

2. The importance of nasal cultures is shown by the fact that in routine cultures taken from carriers, 26 per cent. were positive from the nose.

3. Cultures from chronic carriers should be tested for virulence.

4. The carrier state is maintained by some underlying pathologic condition of the affected tissues.

5. In the great majority of cases the carriers harbor the bacilli in the tonsils; a few carry the germs in the nose only; a small group maintains the infection in both nose and tonsils.

6. Conclusions based on the results of local treatment should be founded on careful and prolonged bacteriologic study. Cultures should be taken immediately before treatment, or, if local treatment is being administered, this should be suspended for a number of days before cultures are taken. The results of local treatment are problematical, since the organisms are situated deeply in the tissues.

TABLE 2.—OCCURRENCE OF DIPHTHERIA BY ORGANIZATIONS

Organization	Source	Carriers Per Cent.	Cases Per Cent.
137th Infantry	Rural	19.1	24.2
138th Infantry	Urban	6.7	6.6
139th Infantry	Rural	9.7	13.9
140th Infantry	Rural and urban	9.2	9.3
128th Field Artillery	Urban	1.3	1.8
129th Field Artillery	Rural and urban	5.1	4.6
130th Field Artillery	Rural	5.3	3.9
128th Machine Gun Battalion	Rural	2.7	1.8
129th Machine Gun Battalion	Rural	1.3	0.4
130th Machine Gun Battalion	Rural	2.3	1.7
110th Engineers	Rural and urban	3.0	4.9
110th Sanitary Train	Rural	3.0	3.6
110th Ammunition Train	Rural and urban	3.0	2.8
110th Military Police	Rural	4.3	3.2
110th Supply Train	Urban	1.0	1.1
110th Field Signal Battalion	Rural	0.4	1.3
110th Trench Mortar Battalion	Rural	0.4	0.0
Base Hospital	Rural and urban	16.7	10.6
Quartermaster	Rural and urban	3.2	2.1
Miscellaneous	Rural and urban	2.3	2.2

7. In persistent carriers in whom the focus of infection is the tonsil, enucleation offers the only certain procedure for terminating the carrier state.

8. The most persistent nasal carriers are those in whom chronic inflammatory or atrophic processes are found. It is almost impossible, in view of the varying culture returns, to state when the condition has finally cleared.

9. Centralization of authority is necessary for the control of an epidemic of diphtheria and diphtheria carriers in camp. Release of patients from quarantine should be under the supervision of the laboratory.

10. During an epidemic, patients should not be admitted to a clean ward unless they have had at least two successive negative cultures from the nose and throat.

11. Improperly constructed and improperly worn masks give a sense of false security.

12. The hospital personnel should be given a Schick test, and those giving a positive reaction should be immunized with toxin-antitoxin mixture.

13. Toxin for the Schick test should be prepared fresh, and no diluted toxin should be used after twenty-four hours. The undiluted toxin should be kept in the dark and in a refrigerator.

14. Intermittent chronic carriers should be employed as attendants in diphtheria wards or in quarantine camps. They should be separated from the hospital personnel and from their organizations.

15. Diphtheria patients may be discharged from the hospital after they have had at least three negative cultures at three-day intervals. Chronic carriers should not be discharged until cultures taken over a long period of time prove consistently negative.

We take this opportunity of expressing our appreciation for the cooperation accorded us during this study to the following members of the staff of the base hospital: Major A. C. Magruder, Capts. W. B. Post, E. E. Hopkins, A. W. Cox, H. E. Blanchard, R. Appleberry and A. E. Edgerton, Lieut. F. H. Thorne, Miss Marjorie Bates, Miss Dorothy Loomis, and Pvt., First Class, Stephens Moore.

THE PROTECTIVE QUALITIES OF THE GAUZE FACE MASK

EXPERIMENTAL STUDIES

DAVID A. HALLER, M.D. (POCAHONTAS, VA.)
Major, M. R. C., U. S. Army
AND
RAYMOND C. COLWELL
First Lieutenant, S. C., N. A.
CAMP GRANT, ROCKFORD, ILL.

The use of the face mask by surgeons and their assistants to protect clean operative fields which they otherwise would spray with their own mouth organisms at every cough or sneeze is an old and well established procedure. The utilization of the face mask to protect the wearer from droplet infection in the presence of those ill with acute infectious diseases is likewise now a well established custom owing in large part to the careful studies at the Durand Hospital in Chicago. Weaver[1] has shown its efficacy when used in this institution in protecting attendants on infectious disease cases both from contracting these diseases and from becoming carriers of them. Capps[2] has published statistics tending to confirm the work of Weaver and has proposed a new adaptation for the face mask, the essential idea being to use this mask to protect patients from cross-infection in the ambulances, and in the admission rooms and wards of the hospital. The clinical results of this adaptation of the face mask were described by Capps[3] recently.

The work described in this paper was carried out for several reasons. The masks used at this hospital have come from several different sources. Masks found in use in the various wards on the same day showed extreme variation in the number of layers of gauze. Some were made with only three layers, and were obviously too thin. Others were made with eight layers, and these were quite hard to breathe through; also they were very warm and uncomfortable. The gauze of which the masks were made varied in quality,

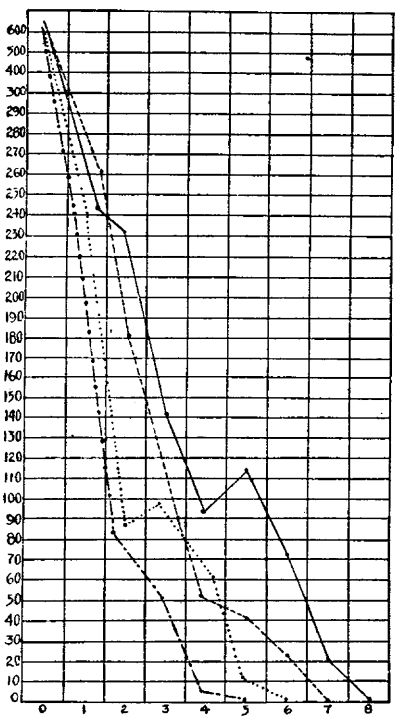
1. Weaver, G. H.: The Value of the Face Mask and Other Measures, THE JOURNAL A. M. A., Jan. 12, 1918, p. 26.
2. Capps, J. A.: A New Adaptation of the Fase Mask in Control of Contagious Diseases, THE JOURNAL A. M. A., March 30, 1918, p. 910.
3. Capps, J. A.: Measures for the Prevention and Control of Respiratory Infections in Military Camps, THE JOURNAL A. M. A., Aug. 10, 1918, p. 448.

some being as fine as twenty-eight strands to the warp and twenty-four to the woof per inch. Other specimens showed twenty strands to the warp and fourteen to the woof per inch. The masks varied in size. Some we believed to be too small. A great difference was noted in the same mask before and after being washed. In addition to this variation in the masks, we judged that there was some difference between the protection afforded the uninfected individual by a mask when placed over the mouth and nose of the one infected and when an identical mask was placed over the mouth and nose of the uninfected, for the reason that in the latter situation the mask is at a greater distance from the source of the organisms, and they are not propelled against the mask with the force that they are when it is directly subjected to currents of air expelled from the mouth carrying numerous droplets of mucus and saliva, each one of which probably carries many organisms.

One of us was found to be a badly infected carrier of typical pneumococci (Type IV) which could be distinguished on human blood agar plates from air-borne organisms of the room which were deposited on plates of the same mediums exposed at the same time in the same room. It was determined to have this individual cough directly at a Petri dish containing this medium, first without a mask and later with masks over the face, each succeeding mask being thicker by one layer than the preceding one. Masks tested varied in thickness from one to eight layers. The gauze used was Bauer and Black's or the equivalent of their specimens called, (1) B and B (32 by 26); (2) L and L (28 by 24); (3) Lakeside (24 by 20); (4) Dearborn (20 by 14).

The coughing was kept as nearly constant as possible, both in force and in the number of coughs. It was soon found that the first few coughs were usually rather unproductive and that it was necessary to have the individual cough several minutes before the coughs became roughly equal in productiveness. The Petri dishes were in every case at a distance of from 12 to 14 inches from the face. The gauze was unwashed and was sterilized in the steam autoclave at 15 pounds pressure for thirty-nine minutes and then allowed to dry before being used. A chart of the protocol of an experiment is given herewith. It will be noticed that if one takes the sum of the strands counted in the warp and in the woof in the case of each quality of gauze—B and B, 32 and 26, total 58; L and L, 28 and 24, total 52; Lakeside, 24 and 20, total 44; Dearborn, 20 and 14, total 34—and multiplies in each case by the number of layers of gauze necessary in each case to protect fully the exposed plate, these figures quite closely correspond: $5 \times 58 = 290$; $6 \times 52 = 312$; $7 \times 44 = 308$; $9 \times 34 = 306$.

The total number of colonies coughed through various layers of gauze cannot be compared directly with the total number of colonies coughed through one of the same series of masks resterilized and used at some other time, for the contamination of the mouth is not at all the same at different times. A complete series of masks must be run through at one sitting. This is done on several different occasions and the results for each mask averaged. The results with two or more patients can be compared only by taking the number of colonies on the respective control plates as a total and expressing all other counts in percentages of this total. The percentages can then be directly compared. The only constant feature in regard to the various masks seems to be the thickness at which absolute protection of the place is reached. This can be tested with very little trouble and without going through the entire series of masks. The conclusion reached is that the amount of gauze placed in superimposed layers necessary to give fully complete protection when the mask is worn over the face of the one infected lies very close to the equivalent of 300 strands of cotton fiber to the square inch.



Experiment with gauze over face: line of dots and dashes, B and B (32 by 26); dotted line, L and L (28 by 24); broken line, Lakeside (24 by 20); solid line, Dearborn (20 by 14).

In several instances the experiment was conducted as described, and in addition after each mask had been worn from five to fifteen minutes another Petri dish was then exposed and coughed at in the same manner. The object was to see whether the filtration was as efficient after the mask had been worn for some time as it was when first put on. The workers were biased in their belief that the mask would not be sufficient, and quite a large number of parallel and control experiments were necessary to remove this bias. It was, however, conclusively shown that no more organisms penetrate the mask after it has been worn for thirty minutes than when it is first applied to the face, provided, of course, all other factors remain constant. The mask if dried and reversed will become not a filter but a disseminator of organisms. Experiments to determine the effect of drying used masks which are then reapplied to the face have been so at variance with each other as to be quite inconclusive. It is our opinion, however, that this drying process is rendered practically harmless when the mask is reapplied without reversal after the patient has breathed through the mask several times and the expired air has been allowed to moisten it again. It seems that the practice as followed here of marking the face side of the mask by a small strand of black thread is a very good one and should be followed out in all masks.

Our second series of experiments was directed toward a determination of how many superimposed layers of gauze are necessary to protect when applied over the face of the uninfected, rather than over the mouth of the infected. To represent the recipient, a Petri dish was masked and coughed at from a distance of from 12 to 14 inches with no mask over the face of the subject. One feature entirely neglected in this experiment which is present in the actual clinical test

of the mask is the inspiratory suction through the mask. The same series of masks were used although only one quality of gauze was completely worked out. This was the Lakeside (24 by 20). Five layers were necessary to protect the plate completely, which amount represents 220 strands of cotton fiber to the square inch.

A third series of tests were made with duplicate masks; one was placed over the face and one over the exposed plate, each succeeding mask being increased in thickness by one layer of gauze. The series embraces all thicknesses from one to eight. The gauze used for the series was Lakeside (24 by 20). The figures obtained tend to show that cotton fibers in superimposed layers of gauze to the extent of 350 to the square inch equally divided between the infected and uninfected will prevent droplet infection. This result may be interpreted as inconsistent with the figures of the protocol given. This apparent inconsistency is, we believe, quite within the limit of error of the methods used. It can be shown that the mask over the face of the infected is of value in the prevention of the uninfected when used in addition to the mask over the plate which represents the uninfected.

Experiments made with washed gauze demonstrated the following facts: The better qualities of gauze B and B (32 by 26), L and L (28 by 24) and Lakeside (24 by 20) become more efficient through shrinkage of the fiber, and if too thick at the outset become almost unbearable after repeated washing. Here also there is some question whether or not most of the respiratory exchange takes place about the edges of the mask, rather than through it. With the very poor quality of gauze, Dearborn (20 by 14), there is a decided tendency for the gauze to pull apart and leave very large gaps in the individual layers. We are of the opinion that this gauze should never be used for this purpose.

Work with the reknit gauze has demonstrated that it is almost impossible, because of its remarkable stretching, to estimate its efficiency. Even under ordinary conditions it does not remain the same for more than a few minutes at a time. We hesitate to recommend its use, as we have seen a thick mask so stretched out and thinned after an hour's wear that it was quite obviously useless.

A small amount of work was done with Turkish toweling. Preliminary experiments tend to show that one layer of this material makes a highly efficient droplet filter, and it is comfortable to wear. The question of expense, and also the question of the effect of wear on this material, are to be considered.

SUGGESTIONS FOR MASKS

1. It is our belief that gauze of the quality of Lakeside (24 by 20) or L and L (28 by 24) should be used in four layers, B and B (32 by 26) in three layers, provided all persons are masked. In case only the infected are masked, Lakeside (24 by 20) should be seven layers thick, L and L (26 by 24) six layers, and B and B (32 by 26) five layers. If the masks of this thickness are used, the ambulances and receiving offices and particularly the clothing of uninfected patients would probably not become infected.

2. Masks should be 8 inches in length with the edges turned in and stitched. They should be 5 inches in width.

3. Two braids should be used, each 1 yard long and sewed along the upper and lower borders of the mask so as to leave a free end 14 inches long at each side.

4. The masks should be marked on the face side by a black thread tied in the gauze.

THE ARMY SHOE AND MILD FOOT DISABILITIES

J. TORRANCE RUGH, M.D.
Lieutenant-Colonel, M. C., U. S. Army.
PHILADELPHIA

Extensive foot inspections were made of the soldiers who were trained during the latter half of 1917 and early part of 1918. These inspections were first made when the men were inducted into service and while the feet still showed the abnormal conditions that were present in civil life, and again before they were sent overseas. Comparison of the results of the two examinations disclosed that marked changes had occurred, and the experience of civil orthopedic practice is verified by these observations. These changes have been almost uniformly favorable to better function of the feet, and when unfavorable results have occurred, the reason has been readily traced.

In endeavoring to account for the marked changes observed, there are two factors that stand out as most potent. First is the Army shoe and second is the increased personal care and interest in foot health on the part of the officers and men from the instruction by the orthopedic surgeons.

Extensive observation (covering several hundred thousasd cases) shows that 98 per cent. of the recruits can be fitted with the Army shoe. This fact alone is the strongest possible recommendation for its use, but an additional fact still more strongly recommends it. This is the beneficial influence of the shoe on the foot of the wearer. When a shoe is properly fitted at the beginning of service, there should be about two-thirds inch between the end of the longest toe and the end of the shoe. After from four to six months of training there should be at least half an inch. The heel should be held fairly snug in the shoe, the vamp should fit smoothly over the forefoot, and the ball of the foot should rest in its seat near the posterior turn of the sole. In fitting shoes, it must always be remembered that a shoe will enlarge sidewise but never lengthwise. Also, that repairing tends to shorten a shoe, and rebuilding actually does shorten it.

Short shoes cause more foot troubles than narrow ones; hence the great need of the two-thirds inch room in the length of the shoe to accommodate the lengthening of the foot in the first four or five months of training. This length and breadth of shoe permits a degree of function hitherto unknown to the foot. There is greater freedom of toe action, which affects both muscles and joints. This is followed directly by lengthening of ligaments, increase in size of muscles and alteration of relations of all the anatomic elements of the foot. These factors contribute directly to an increase in the size of the part. I have repeatedly seen cases in which the original size of the shoe had been strongly objected to as being entirely too large, but after a few months of intensive training and perhaps using extra or thicker socks, the fit was entirely satisfactory by reason of the development of the foot.