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PUBLIC HEALTH SERVICES AND SYSTEMS RESEARCH

Public Health Emergency Preparedness at the Local Level: Results of a National Survey

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Objective. To study the relationship between elements of public health infrastructure and local public health emergency preparedness (PHEP).
Data Sources/Study Setting. National Association of County and City Health Officials 2005 National Profile of Local Health Departments (LHDs).
Study Design. Cross-sectional.
Principal Findings. LHDs serving larger populations are more likely to have staff, capacities, and activities in place for an emergency. Adjusting for population size, the presence of a local board of health and the LHDs' experience in organizing PHEP coalitions were associated with better outcomes.
Conclusions. The results of this study suggest that more research should be conducted to investigate the benefit of merging small health departments into coalitions to overcome the inverse relationship between preparedness and population size of the jurisdiction served by the LHD.

Key Words. Emergency preparedness, public health system research, survey

Since 9/11, the United States has invested over U.S.$7 billion in the state and local public health infrastructure to enhance its ability to respond to public health emergencies. Despite the magnitude of this investment, the Institute of Medicine (IOM) recently concluded that "it is difficult to measure objectively the progress that has been made and the preparedness gaps" that remain (Institute of Medicine 2008). Despite the development of several instruments intended to measure local public health capacity in general and emergency preparedness (EP) in particular (U.S. Department of Health and Human Services 2002; Levi, Vinter, and Segal 2007; Centers for Disease Control and Prevention 2008), there are still minimal nationally representative data on local public health emergency preparedness (PHEP).

To address this gap, we analyzed the data from a national survey of local health departments (LHDs) conducted in 2005 by the National Association of

County and City Health Officials (NACCHO) in cooperation with the Centers for Disease Control and Prevention (CDC). Intended to provide information about general public health services, the survey also included a set of variables related to PHEP. We used these variables to study the relationship between specific elements of public health infrastructure and LHDs' PHEP.

The literature on public health performance shows that LHDs' characteristics, such as the size of the population served, the organizational structure of the LHD, and the interaction between LHDs and communities' partners, are factors associated with performance outcomes (Erwin 2008). In particular, there is some evidence demonstrating the association between the existence of a board of health (BOH) and public health performance (Mays et al. 2006; Bhandari et al. 2008). Similarly, there is evidence of the association between performance and the degree of interaction between the LHD and communities' partners (Lovelace 2000; Erwin 2008). This knowledge, coupled with data availability, provided the basis for our selection of the following potential predictors of preparedness outcomes: the size of the population served, the presence of a BOH, and the LHD's participation in organizing coalitions.

METHODS

In 2005, NACCHO surveyed 2,864 LHDs across the United States using an online instrument. The study used the following definition of an LHD "an administrative or service unit of local or state government concerned with health, and carrying some responsibility for the health of a jurisdiction smaller than the state" (NACCHO 2005a). The sample was stratified by population size, with LHDs serving the largest populations oversampled, and weights prepared to adjust for this sampling and nonresponse. Copies of the instrument and study methodology are available on the NACCHO website (NACCHO 2005b). We used these data to investigate the relationship between levels of PHEP and (1) population size of the community served by the LHD, (2) presence of a BOH, (3) and LHDs' participation in organizing coalitions for EP and response purposes.

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Measures of PHEP

Items. There is no consensus about the most important or legitimate measures of PHEP (Nelson et al. 2007). To identify EP measures, we selected 21 items from over 350 in the survey that, consistently with the conceptual framework developed by Nelson and colleagues, could be considered indicators of EP efforts and outcomes. These indicators were not meant to cover all aspects of PHEP at the local level, but, rather, were the best approximation in a survey designed for other purposes.

In addition, items were combined into four domains as follows: "EP-Staff" related to the availability of a public information specialist (PIS) and EP coordinator (EPC); "EP-Capacities" related to the availability of specialized services such as communicable/infectious disease activities, syndromic surveillance, hazmat response, emergency medical services (EMS), and laboratory services; "EP-Activities" related to the development and update of an emergency plan, review of legal authorities, participation in drills and exercises, assessment of staff EP competencies, and EP training of staff; and "EP-Performance," related to generic public health activities such as monitoring and surveillance, epidemiology, screening, health education, planning and policy development, enforcement of laws and regulations, outreach and referral, workforce training, and quality improvement efforts that during the previous year were used for EP planning and/or response efforts.

Summary Scales. Factor analysis was used to create summary variables and confirm the structure of the items into domains as reported above. The analysis excluded five items grouped into the "EP-Capacities" domain because the items were distributed in different sections of the questionnaire and therefore potentially completed by more than one respondent per agency.

Factors were transformed into summary variables using both continuous and indicator variables. Two types of continuous variables were created as follows: (1) using the sum of the responses to each item and (2) using their factor scores. Indicator variables were defined as follows: "EP-Staff" equals 1 when the LHD employees both a PIS and an EPC; "EP-Capacities" equals 1 when the LHD performs at least three out of five services; "EP-Activities" equals 1 when the LHD performs at least four out of five activities, and "EP-Performance" equals 1 when the LHD performs six out of nine activities belonging to this scale.

Predictors of EP. Based on the literature, we expected to find a large population size, BOH presence, and experience in organizing coalitions to be associated with better PHEP outcomes. The size of the population served by the LHD (2000 Census), the presence of a BOH, and experience in organizing coalitions were self-reported. We grouped LHDs according to the following four categories of population size: (1) <25,000, (2) 25,000–49,999, (3) 50,000–199,999, (4) >200,000. These categories included approximately one-quarter of the sample each and matched those used by NACCHO (2005b).

Statistical Methods. For each of the 21 EP questions and for each of the four indicator summary variables we calculated the proportion of agencies performing the given function by category of population size, presence of a BOH, and participation in coalitions. Differences in proportions were tested using the corrected Pearson χ^2 test. Subsequently, the role of population size was investigated as a possible confounder and/or effect modifier by the use of a logistic regression model. All analyses incorporated weights prepared by NACCHO to reflect the stratified sampling frame.

Factor analysis was used to combine the items into summary variables as follows: The Kaiser–Guttman rule (eigenvalue >1) and the corresponding scree plot results were used to determine the number of factors to be retained. Factors were rotated using varimax rotation and defined by items with loadings >0.40. Subsequently, summary variables were created from the retained factors and linear regression was used to assess the impact of the independent variables, including sample weights.

Data were analyzed using *STATA*, version 9. Significance was set at $\alpha = 0.05$.

Results

NACCHO received 2,300 questionnaires (80 percent response rate), of which 2,296 had answers to at least 1 of the 21 preparedness items that were selected for our analysis. Missing values were on average <1 percent per item. The factor analysis confirmed the hypothesized structure. A three-factor solution, accounting for 48 percent of the total variance, was interpreted as meaningful. Therefore, the association between independent variables and PHEP outcomes was investigated using summary variables in addition to single items.

Population Size

Population data were available for 2,292 LHDs, ranging from 313 to 9,998,371 residents, with a mean of 130,838 (SD 426,592) and a median of 34,273. Population size was consistently and significantly related to preparedness activities and capacities (Table 1). For 20 out of 21 items, a significant difference (chi test, $p < .01$) was found in the proportions of LHDs able to perform activities across communities grouped by population size. The proportion increased with the size of the population served by the LHD, with large differences between the most and least populous communities. Most dramatically, 60.5 percent of the LHDs serving the largest communities (>200,000 residents) reported having a PIS, compared with 3.2 percent in the smallest communities (<25,000).

The same pattern was found when data were analyzed using summary scales (Table 2 and Figure 1). For the four scales, the ratio between the largest and the smallest communities ranged from more than 20:1 for EP-Staff to approximately 3:2 for EP-Activities. Similar results were obtained when summary variables were treated as continuous variables either using factor scores or the simple sum of items (all β coefficients were positive with p values $< .05$).

Board of Health

Information about the presence of a BOH was available for 2,293 LHDs; of these 1,707 (74.4 percent) had a BOH. The relationship between having a BOH and PHEP outcomes was significant for 6 out of 21 EP-Activities, but for 2 of these 6 activities it worked in a direction opposite to what was expected: having a BOH was negatively associated with the LHD's ability to employ a PIS and perform EMS activities. Having a BOH was positively associated with better outcomes for several activities, namely review of legal authorities, writing or updating of an emergency plan, conducting drills and exercises, and training. A similar pattern was found using summary scales: 9.4 percent of LHDs with a BOH had both a PIS and EPC compared with 15.7 percent of those without a BOH, whereas 73.3 percent of LHDs with a BOH achieved the EP-Activities outcome compared with 61.5 percent LHDs without a BOH ($p \leq .0001$).

These relationships suggest an interaction between population size and the presence of a BOH, which led us to explore their joint relationship with PHEP outcomes using a logistic regression model for each of the four summary variables. In this analysis, population size was a negative confounder for EP-Capacities and EP-Performance and a positive confounder for EP-Staff

Table 1: Preparedness by Population Size, Presence of a Board of Health, and Participation in Coalitions—All Selected Preparedness Items

Variable (n)	*Population Size (n) Categories: (1) < 25,000 (2) 25,000–49,999 (3) 50,000–199,999 (4) ≥ 200,000*	*p Value*	*Presence of a Board of Health (n)*	*p Value*	*Participation in Coalitions (n)*	*p Value*
Public information specialist (Q1—$n = 1{,}828$)	(1) 3.2% (26) (2) 7.5% (44) (3) 21.6% (64) (4) 60.5% (78)	<.0001	Yes 10.1% (142) No 16.8% (71)	<.0001	Yes 17.8% (41) No 17.9% (22)	.9824
Emergency preparedness coordinator (Q2—$n = 1{,}981$)	(1) 34.8% (307) (2) 52.6% (329) (3) 71.8% (240) (4) 93.8% (128)	<.0001	Yes 50.6% (777) No 51.3% (228)	.8213	Yes 64.3% (157) No 47.5% (62)	.0053
Infectious diseases (Q3—$n = 2{,}290$)	(1) 79.8% (875) (2) 90.9% (638) (3) 95.9% (334) (4) 95.3% (134)	<.0001	Yes 89.4% (1,558) No 78.0% (425)	<.0001	Yes 93.2% (246) No 77.8% (123)	.0001
Syndromic surveillance (Q4—$n = 2{,}281$)	(1) 22.1% (241) (2) 29.9% (209) (3) 39.9% (138) (4) 55.7% (78)	<.0001	Yes 30.3% (526) No 26.1% (142)	.0573	Yes 41.5% (109) No 25.6% (41)	.0025
Hazmat response (Q5—$n = 2{,}286$)	(1) 14.1% (154) (2) 20.4% (143) (3) 22.2% (77) (4) 26.4% (37)	<.0001	Yes 18.7% (326) No 16.0% (87)	.1641	Yes 26.1% (69) No 15.0% (24)	.0165

EMS (Q6—$n = 2{,}293$)	(1) 3.9% (43) (2) 4.3% (30) (3) 7.0% (25) (4) 18.0% (25)	<.0001	Yes 4.2% (74) No 9.1% (49)	<.0001	Yes 5.1% (13) No 4.2% (7)	.6721
Lab services (Q7—$n = 2{,}282$)	(1) 20.0% (219) (2) 25.4% (177) (3) 38.7% (135) (4) 59.3% (84)	<.0001	Yes 26.2% (455) No 29.6% (161)	.1338	Yes 31.3% (83) No 24.6% (39)	.1608
Written plan (Q8—$n = 2{,}296$)	(1) 81.3% (893) (2) 92.6% (650) (3) 96.0% (336) (4) 97.1% (137)	<.0001	Yes 91.6% (1,599) No 77.0% (421)	<.0001	Yes 95.1% (252) No 80.0% (127)	.001
Legal authorities (Q9—$n = 2{,}296$)	(1) 51.2% (562) (2) 62.0% (435) (3) 77.5% (271) (4) 84.6% (119)	<.0001	Yes 64.0% (1,118) No 50.1% (274)	<.0001	Yes 76.2% (202) No 45.4% (72)	<.0001
Drills and exercises (Q10—$n = 2{,}296$)	(1) 83.8% (920) (2) 92.8% (652) (3) 97.7% (342) (4) 98.4% (139)	<.0001	Yes 90.9% (1,587) No 85.8% (470)	.003	Yes 97.5% (258) No 81.1% (128)	<.0001
Competencies assessment (Q11—$n = 2{,}296$)	(1) 58.8% (646) (2) 72.4% (509) (3) 79.2% (277) (4) 82.9% (117)	<.0001	Yes 68.6% (1,197) No 65.1% (357)	.1681	Yes 78.3% (207) No 51.8% (82)	<.0001
Training (Q12—$n = 2{,}296$)	(1) 75.7% (831) (2) 88.4% (621) (3) 94.3% (330) (4) 96.1% (135)	<.0001	Yes 86.1% (1,504) No 76.2% (417)	<.0001	Yes 93.1% (246) No 74.3% (118)	<.0001
Monitoring and surveillance (Q13—$n = 423$)	(1) 59.1% (90) (2) 68.6% (90) (3) 76.5% (73) (4) 93.0% (43)	.0001	Yes 70.8% (229) No 65.9% (65)	.4119	Yes 84.1% (223) No 45.5% (72)	<.0001

continued

Table 1. *Continued*

Variable (n)	*Population Size (n) Categories: (1)< 25,000 (2) 25,000–49,999 (3) 50,000–199,999 (4) ≥ 200,000*	*p Value*	*Presence of a Board of Health (n)*	*p Value*	*Participation in Coalitions (n)*	*p Value*
Epidemiologic activities (Q14—$n = 423$)	(1) 34.4% (52) (2) 42.9% (56) (3) 63.0% (60) (4) 81.2% (38)	<.0001	Yes 50.2% (162) No 43.3% (43)	.2572	Yes 60.0% (159) No 29.4% (47)	<.0001
Screening (Q15—$n = 423$)	(1) 14.0% (21) (2) 14.8% (19) (3) 23.0% (22) (4) 24.5% (11)	.1523	Yes 16.7% (54) No 19.7% (20)	.5140	Yes 24.3% (64) No 5.9% (9)	<.0001
Health education (Q16—$n = 423$)	(1) 40.9% (62) (2) 58.8% (77) (3) 62.3% (59) (4) 75.4% (35)	.0001	Yes 54.3% (176) No 57.0% (57)	.6651	Yes 68.5% (181) No 32.4% (51)	<.0001
Policy development (Q17—$n = 423$)	(1) 61.3% (93) (2) 78.0% (102) (3) 79.4% (75) (4) 90.9% (42)	.0001	Yes 76.2% (247) No 65.8% (65)	.0701	Yes 94.4% (250) No 39.2% (62)	<.0001
Enforce laws (Q18—$n = 423$)	(1) 18.3% (28) (2) 21.4% (28) (3) 29.6% (28) (4) 49.5% (23)	<.001	Yes 24.6% (80) No 27.2% (27)	.5939	Yes 33.2% (88) No 11.8% (19)	<.0001
Outreach (Q19—$n = 423$)	(1) 24.7% (37) (2) 41.9% (55) (3) 37.4% (35) (4) 50.1% (23)	<.01	Yes 37.1% (120) No 30.7% (30)	.2574	Yes 47.5% (126) No 15.9% (25)	<.0001

Workforce training (Q20—$n = 423$)	(1) 66.7% (101) (2) 72.1% (94) (3) 82.3% (78) (4) 91.8% (42)	<.01	Yes 76.6% (248) No 68.0% (67)	.1284	Yes 89.6% (237) No 49.5% (78)	<.0001
Evaluation and quality improvement (Q21—$n = 423$)	(1) 49.5% (75) (2) 55.7% (73) (3) 61.6% (58) (4) 84.0% (39)	<.001	Yes 59.0% (191) No 54.2% (54)	.4409	Yes 76.2 (202) No 27.3% (43)	<.0001

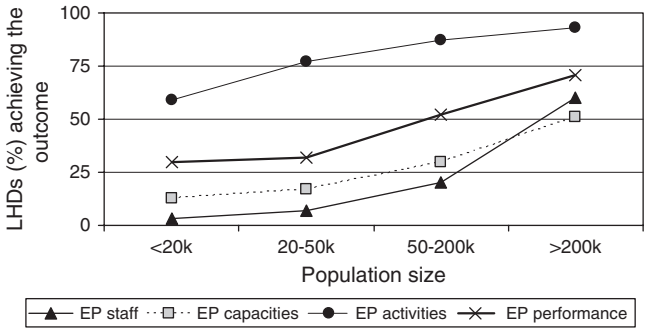
Table 2: Preparedness by Population Size, Presence of a Board of Health, and Participation in Coalitions—Composite Scales

Variable (n)	*Population Size (n) Categories: (1)< 25,000 (2) 25,000–49,999 (3) 50,000–199,999 (4) ≥ 200,000*	*p Value*	*Presence of a Board of Health (n) Univariate ORs and ORs Adjusted for Population Size*	*p Value*	*Participation in Coalitions (n) Univariate ORs and ORs Adjusted for Population Size*	*p Value*
EP-Staff ($n = 1{,}794$)	2.7% (22)	<.0001	*Proportions*	.0001	*Proportions*	.8293
	7.1% (41)		Yes 9.4% (131)		Yes 17.7% (40)	
	20.0% (58)		No 15.7% (64)		No 16.8% (20)	
	58.3% (74)		*ORs (95% CI)*		*ORs (95% CI)*	
			Univariate: 0.56 (0.42, 0.75)		Univariate: 1.06 (0.60, 1.88)	
			Adjusted: 0.76 (0.54, 1.08)		Adjusted: 0.89 (0.46, 1.74)	
EP-Capacities ($n = 2{,}255$)	12.9% (139)	<.0001	*Proportions*	.6357	*Proportions*	.0582
	17.2% (119)		Yes 19.0% (326)		Yes 27.8% (73)	
	30.0% (103)		No 19.9% (106)		No 19.1% (30)	
	49.8% (70)		*ORs (95% CI)*		*ORs (95% CI)*	
			Univariate: 0.94 (0.74, 1.20)		Univariate: 1.63 (0.98, 2.72)	
			Adjusted: 1.05 (0.81, 1.34)		Adjusted: 1.46 (0.86, 2.47)	
EP-Activities ($n = 2{,}292$)	58.6% (644)	<.0001	*Proportions*	<.0001	*Proportions*	<.0001
	76.4% (537)		Yes 73.3% (1,279)		Yes 85.8% (227)	

	86.1% (301)		No 61.5% (337)		No 53.9% (85)	
	92.0% (130)		*ORs (95% CI)*		*ORs (95% CI)*	
			Univariate: 1.17 (1.37, 2.13)		Univariate: 5.19 (3.03, 8.87)	
			Adjusted: 1.86 (1.48, 2.36)		Adjusted: 5.03 (2.85, 8.90)	
EP-Performance ($n = 423$)	29.0% (44)	$< .0001$	*Proportions*	.9275	*Proportions*	$< .0001$
	32.6% (43)		Yes 40.3% (130)		Yes 59.4% (157)	
	53.1% (50)		No 39.8% (39)		No 8.1% (13)	
	71.5% (33)		*ORs (95% CI)*		*ORs (95% CI)*	
			Univariate: 1.02 (0.63, 1.66)		Univariate: 16.65 (8.70, 31.9)	
			Adjusted: 1.17 (0.70, 1.95)		Adjusted: 17.19 (8.76, 33.7)	

OR, odds ratio; CI, confidence interval.

Figure 1: Percentage of Local Health Departments Achieving the Following Outcomes by Population Size: EP-Staff: Two Positive Responses for Two Items; EP-Capacities: Three Positive Responses for Five Items; EP-Activities: Four Positive Responses for Five Items; EP-Performance: Six Positive Responses for Nine Items



and EP-Activities. After adjusting for population size, having a BOH had a positive effect on all summary variables; however, the effect was statistically significant only for the EP-Activities scale. LHDs with a BOH had 1.86 times greater odds of being able to perform four out of five EP-Activities (odds ratio = 1.86, 95 percent confidence interval 1.48, 2.36) (Table 2). Similar results were obtained using EP-Activities as a continuous variable (sum of items) in the linear regression model adjusting for population size ($\beta = 0.14$, p value $<.05$). This result was consistent but not significant when the outcome variable was the factor score.

Coalitions

The question about participation in organizing coalitions was asked only of the 519 agencies completing module three. Among the respondents (423), 275 (65 percent) reported having worked in such activity. For 18 of 21 items considered and for two of the four summary variables (EP-Activities, EP-Performance, and EP-Capacities was just short of significance), LHDs that worked to organize coalitions were better prepared than those who did not ($p<.05$). Seeing the impact of population size on the effect of having a BOH, we tested whether population size was a confounder of the relationship between having participated in coalitions and PHEP outcomes, but the effect was not substantially changed (Tables 1 and 2). Similar results were found when

the summary variables were tested as continuous variables with better outcomes for LHDs with experience in creating coalitions (all β coefficients were positive with p values $<.05$). Results were not significant when using the factor score as outcome variable for EP-Staff, again likely because of a loss of power.

Discussion

Although developed to address essential public health services of all types, the NACCHO's 2005 Profile provides useful information on EP-Activities and EP-Capacities. The NACCHO profile has a large sample size, high response rate, and is nationally representative. Because it is a general-purpose survey, we believe the response is less likely to be biased to accentuate a single program such as PHEP.

The most consistent result in this analysis is that LHDs' PHEP activities are strongly and consistently associated with the jurisdiction's population size. LHDs serving the largest populations, for instance, are more than 20 times likely to have a PIS and EPC than departments serving small populations. This overall pattern is consistent with the findings of Mays et al. (2006) that population size is one of the strongest predictors of LHDs' performance. Increasing the size of the population served is obviously not a policy lever. However, these results may suggest a benefit in merging small health departments in regional structures and the need of further research to test the effectiveness of such an approach (Koh et al. 2008; Stoto 2008).

Having a BOH was positively related to EP-Activities, but negatively related to EP-Staff. This contradiction reflects the limited impact of BOHs on LHDs' performance found by Bhandari et al. (2008). However, after adjusting for population size, only the positive association with EP-Activities remained. Our interpretation is that having a BOH means different things depending on the size of the community. In small communities, especially in New England, a BOH is often a substitute for a professionally staffed LHD. In large communities a BOH might provide political support to help professional staff achieve preparedness goals.

For most of the items considered, as well for two of the four summary scales (EP-Activities and EP-Performance), LHDs that worked to organize coalitions were more likely to have achieved preparedness goals than those who did not. The interpretation of this result is difficult because the survey is not specific about the meaning of "to organize coalitions."

Limitations

The NACCHO profile, designed as a general-purpose survey, does not provide the most relevant information about PHEP. Whether EMS services are provided by the health department, for instance, is not the same as the availability, or the quality, of these services in the community. In addition, the impact of extensive efforts to set up regional structures for PHEP needs further investigation (Koh et al. 2008). In particular, some of the PHEP activities and capacities that are not reported by LHDs serving smaller communities might be provided by regional entities or the state health department.

The NACCHO profile is also limited in the focus of its preparedness questions on capacities rather than capabilities. PHEP *capacities* represent the resources—infrastructure, response mechanisms, knowledgeable and trained personnel—that a public health system draws upon. While minimum capacity levels are necessary, capacity alone is not a sufficient measure of preparedness. *Capabilities*, on the other hand, describe the functional or operational actions a public health system can take to effectively identify, characterize, and respond to emergencies (Stoto et al. 2005). For example, the items that make up the EP-Performance scale all ask about whether LHDs have performed various activities, but they fail to address their capacity to act during an actual emergency.

Moreover, PHEP requires partnerships with hospitals and physicians, EMS, agricultural and environmental protection agencies, law enforcement, and others (Institute of Medicine 2008). With limited exceptions, the NACCHO profile focuses on LHDs' activities and capacities rather than on the larger public health system.

CONCLUSIONS

In the United States, LHDs that serve larger populations are more likely to have undertaken EP-Activities and have preparedness staff and capacities in place. Adjusting for population size, LHDs served by a BOH are more likely to have written an emergency response plan, reviewed legal authorities, participated in drills and exercises, assessed EP competencies of their staff, and trained the staff. LHDs that participated in EP coalitions are more likely to have met preparedness goals; however, such participation may reflect an interest in preparedness rather than be a causal factor.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article:

Appendix SA1: Author Matrix.

Appendix SA2: Full Wording and Codes of the Questions Selected as Emergency Preparedness Outcomes.

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