Normal distribution problems with answers pdf

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 Biostatistics for the Health Sciences: The Normal Distribution - Exercises questions answersEXERCISES 6.1 Define the following terms in your own words: Continuous distribution Normal distribution Standard normal distribution Probability density function Standardization Standard score score Percentile 6.2 The following questions pertain to some important facts to know about a nor-mal distribution: a. What are three important properties of a normal distribution? b. What percentage of the values are: i. within 1 standard deviation of the mean? ii. 2 standard deviations or more above the mean? iii. 1.96 standard deviations or more below the mean? iv. between the mean and ±2.58 standard deviations? v. 1.28 standard deviations above the mean? 6.3 The following questions pertain to the standard normal distribution: a. How is the standard normal distribution defined? b. How does a standard normal distribution compare to a normal distribution? c. What is the procedure for finding an area under the standard normal curve? d. How would the typical normal distribution of scores on a test administered to a freshman survey class in physics differ from a standard normal distribution? e. What characteristics of the standard normal distribution make it desirable for use with some problems in biostatistics? 6.4 If you were a clinical laboratory technician in a hospital, how would you ap-ply the principles of the standard normal distribution to define normal and abnormal blood test results (e.g., for low-density lipoprotein)? To solve Exercises 6.5 through 6.9, you will need to refer to the standard normal table. 6.5 Referring to the properties shown in Table 6.3, find the standard normal score (Z score) associated with the following percentiles: (a) 5th, (b) 10th, (c) 20th, (d) 25th, (e) 50th, (f) 75th, (g) 80th, (h) 90th, and (i) 95th. 6.6 Determine the areas under the standard normal curve that fall between the following values of Z: a. 0 and 1.00 b. 0 and 1.28 c. 0 and –1.65 d. and 2.33 e. –1.00 and –2.58 6.7 The areas under a standard normal curve also may be considered to be proba-bilities. Find probabilities associated with the area: a. Above $Z = 2.33$ b. Below $Z = -2.58$ c. Above $Z = 1.65$ and below $Z = -1.65$ d. Above $Z = 1.96$ and below $Z = -1.96$ e. Above $Z = 2.33$ and below $Z = -2.33$ 6.8 Another way to express probabilities associated with Z scores (assuming a standard normal distribution) is to use parentheses according to the format: $P(Z > 0) = 0.5000$, for the case when $Z = 0$. Calculate the following probabil-ities: a. $P(Z < -2.90) =$ b. $P(Z > -1.11) =$ c. $P(Z < 0.66) =$ d. $P(Z > 3.00) =$ e. $P(Z < -1.50) =$ 6.9 The inverse of Exercise 6.8 is to be able to find a Z score when you know a probability. Assuming a standard normal distribution, identify the Z score in-dicated by a # sign that is associated with each of the following probabilities: a. $P(Z < \#) = 0.9920$ b. $P(Z > \#) = 0.0005$ c. $P(Z < \#) = 0.0250$ d. $P(Z < \#) = 0.6554$ e. $P(Z > \#) = 0.0049$ 6.10 A first year medical school class (n = 200) took a first midterm examination in human physiology. The results were as follows (= 65, S = 7). Explain how you would standardize any particular score from this distribution, and then solve the following problems: a. What Z score corresponds to a test score of 40? b. What Z score corresponds to a test score of 50? c. What Z score corresponds to a test score of 60? d. What Z score corresponds to a test score of 70? e. How many students received a score of 75 or higher? 6.11 The mean height of a population of girls aged 15 to 19 years in a northern province in Sweden was found to be 165 cm with a standard deviation of 15 cm. Assuming that the heights are normally distributed, find the heights in centimeters that correspond to the following percentiles: a. Between the 20th and 50th percentiles. b. Between the 40th and 60th percentiles. c. Between the 10th and 90th percentiles. d. Above the 80th percentile. e. Below the 10th percentile. f. Above the 5th percentile. 6.12 In a health examination survey of a prefecture in Japan, the population was found to have an average fasting blood glucose level of 99.0 with a standard deviation of 12. Determine the probability that an individual selected at ran-dom will have a blood sugar reading: a. Greater than 120 (let the random variable for this be denoted as X; then we can write the probability of this event as $P(X > 120)$ b. Between 70 and 100, $P(70 < X < 100)$ c. Less than 83, $P(X < 83)$ d. Less than 70 or greater than 110, $P(X > 110) + P(X < 70)$ e. That deviates by more than 2 standard deviations (24 units) from the mean 6.13 Repeat Exercise 6.12 but with a standard deviation of 9 instead of 12. 6.14 Repeat Exercise 6.12 again, but this time with a mean of 110 and a standard deviation of 15. 6.15 A community epidemiology study conducted fasting blood tests on a large community and obtained the following results for triglyceride levels (which were normally distributed): males— $\mu = 100$, $\sigma = 30$; females— $\mu = 85$, $\sigma = 25$. If we decide that persons who fall within two standard deviations of the mean shall not be referred for medical workup, what triglyceride values would fall within this range for males and females, respectively? If we decide to refer persons who have readings in the top 5% for medical workup, what would these triglyceride readings be for males and females, respectively? 6.16 Assume the weights of women between 16 and 30 years of age are normally distributed with a mean of 120 pounds and a standard deviation of 18 pounds. If 100 women are selected at random from this population, how many would you expect to have the following weights (round off to the nearest integer): a. Between 90 and 145 pounds b. Less than 85 pounds c. More than 150 pounds d. Between 84 and 156 pounds 6.17 Suppose that the population of 25-year-old American males has an average remaining life expectancy of 50 years with a standard deviation of 5 years and that life expectancy is normally distributed. a. What proportion of these 25-year-old males will live past 75? b. What proportion of these 25-year-old males will live past 85? c. What proportion of these 25-year-old males will live past 90? d. What proportion will not live past 65? 6.18 The population of 25-year-old American women has a remaining life ex-pectancy that is also normally distributed and differs from that of the males in Exercise 6.17 only in that the women's average remaining life expectancy is 5 years longer than for the males. a. What proportion of these 25-year-old females will live past 75? b. What proportion of these 25-year-old females will live past 85? c. What proportion of these 25-year-old females will live past 95? d. What proportion will not live past 65? 6.19 It is suspected that a random variable has a normal distribution with a mean of 6 and a standard deviation of 0.5. After observing several hundred values, we find that the mean is approximately equal to 6 and the standard deviation is close to 0.5. However, we find that 53% percent of the observations are between 5.5 and 6.5 and 83% are between 5.0 and 6.0. Does this evidence in-crease or decrease your confidence that the data are normally distributed? Explain your answer. Answers: 6.7 a. $P(Z > 2.33) = 0.5 - P(0 < Z < 2.33) = 0.5 - 0.4901 = 0.0099$. b. $P(Z < -2.58) = P(Z > 2.58) = 0.5 - P(0 < Z < 2.58) = 0.5 - 0.4951 = 0.0049$. c. From the table of the standard normal distribution, we see that we want to find the probability that $Z > 1.65$ or $Z < -1.65$ or $p = P(Z < -1.65) + P(Z > 1.65)$. By symmetry $P(Z < -1.65) = P(Z > 1.65)$. So $p = 2P(Z > 1.65)$. We also know that $P(Z > 1.65) = 0.5 - P(0 < Z < 1.65)$. So $p = 1 - 2P(0 < Z < 1.65)$. We look up $P(0 < Z < 1.65)$ in the table for the normal distribution and find it is 0.4505. So $p = 1 - 0.9010 = 0.099$. d. From the table of the standard normal distribution we see that we want to find the probability that $Z > 1.96$ or $Z < -1.96$ or $p = P(Z < -1.96) + P(Z > 1.96)$. By symmetry $P(Z < -1.96) = P(Z > 1.96)$. So $p = 2P(Z > 1.96)$. We also know that $P(Z > 1.96) = 0.5 - P(0 < Z < 1.96)$. So $p = 1 - 2P(0 < Z < 1.96)$. We look up $P(0 < Z < 1.96)$ in the table for the normal distribution and find it is 0.4750. So $p = 1 - 0.95 = 0.05$. e. From the table of the standard normal distribution we see that we want to find the probability that $Z > 2.33$ or $Z < -2.33$ or $p = P(Z < -2.33) + P(Z > 2.33)$. By symmetry $P(Z < -2.33) = P(Z > 2.33)$. So $p = 2P(Z > 2.33)$. We also know that $P(Z > 2.33) = 0.5 - P(0 < Z < 2.33)$. So $p = 1 - 2P(0 < Z < 2.33)$. We look up $P(0 < Z < 2.33)$ in the table for the normal distribution and find it is 0.4901. So $p = 1 - 0.9802 = 0.0198$. 6.9 a. We want $P(Z < \neq) = 0.9920$. We know that since the probability is greater than $0.5 \leq \neq$ is greater than 0. So $P(Z < \neq) = 0.5 + P(0 < Z < \neq) = 0.9920$. So to determine $\neq$ we solve $P(0 < Z < \neq) = 0.9920 - 0.5 = 0.4920$. We look it up and find that 0.4920 corresponds to $\neq = 2.41$. b. We want $P(Z > \neq) = 0.0005$. # is in the upper-right tail of the distribution so $P(Z > \neq) = 0.5 - P(0 < Z < \neq)$. We find $\neq$ by solving $P(0 < Z < \neq) = 0.5 - 0.0005 = 0.4995$. Our table only goes to 3.09 and we see that $P(0 < Z < 3.09) = 0.4990 < .4995$. So $\neq > 3.09$. c. We want $P(Z < \neq) = 0.0250$. This is in the lower tail so $\neq < 0$. $P(Z < \neq) = P(Z > -\neq) = 0.5 - P(0 < Z < -\neq)$. So $P(0 < Z < -\neq) = 0.5 - 0.025 = 0.475$. The table tells us that $-\neq = 1.96$. Therefore $\neq = -1.96$. d. We want $P(Z < \neq) = 0.6554$. Since the probability is greater than 0.5 we know $\neq > 0$. $P(Z < \neq) = 0.5 + P(0 < Z < \neq)$. So $P(0 < Z < \neq) = 0.6554 - 0.5 = 0.1554$. Solving for $\neq$ by table look-up we see that $\neq = 0.40$. e. We want $P(Z > \neq) = 0.0049$. Again, we are in the right tail. So $\neq > 0$. $P(Z > \neq) = 0.5 - P(0 < Z < \neq)$. We must therefore determine $\neq$ that satisfies $P(0 < Z < \neq) = 0.5 - 0.0049 = 0.4951$. We see that $\neq = 2.58$. 6.10 To standard we take the score and subtract the sample mean and then divide by the sample standard deviation. Call the raw score W and the standardized score Z. Then since the sample mean is 65 and the sample standard deviation is 7, we set $Z = (W - 65)/7$. a. W = 40. So $Z = (40 - 65)/7 = -25/7 = -3.57$. b. W = 50. So $Z = (50 - 65)/7 = -15/7 = -2.14$. c. W = 60. So $Z = (60 - 65)/7 = -5/7 = -0.714$. d. W = 70. So $Z = (70 - 65)/7 = 5/7 = 0.714$. e. We want to determine the probability that $W > 75$. $Z = (75 - 65)/7 = 10/7 = 1.43$. $P(Z > 1.43) = 0.50 - P(0 < Z < 1.43)$. So $P(0 < Z < 1.43) = 0.5 - 0.4236 = 0.0764$. 6.12 The population has a mean blood glucose level of 99 with a standard deviation of 12. So we normalize by setting $Z = (X - 99)/12$. a. $P(X > 120) = P(Z > 21/12) = P(Z > 1.75) = 0.5 - P(0 < Z < 1.75) = 0.5 - 0.4599 = 0.0401$. b. $P(70 < X < 100) = P(-29/12 < Z < 1/12) = P(-20/12 < Z < 0) + P(0 < Z < 1/12) = P(0 < Z < 20/12) + P(0 < Z < 1/12) = P(0 < Z < 1.67) + P(0 < Z < 0.08) = 0.4525 + 0.0319 = 0.4844$. c. $P(X < 83) = P(Z < -16/12) = P(Z < -1.33) = P(Z > 1.33) = 0.5 - P(0 < Z < 1.33) = 0.5 - 0.4082 = 0, 0918$. d. $P(X > 110) + P(X < 70) = P(Z > 11/12) + P(Z < -29/12) = 0.5 - P(0 < Z < 11/12) + P(Z > 29/12) = 0.5 - P(0 < Z < 0.92) + 0.5 - P(0 < Z < 2.42) = 1 - 0.3212 - 0.4922 = 1 - 0.8134 = 0.1866$. e. If X is outside two standard deviations of the mean Z is either >2 or < –2. So we want to know $P(Z > 2) + P(Z < -2) = 2P(Z > 2) = 2[0.5 - P(0 < Z < 2)] = 1.0 - 2P(0 < Z < 2) = 1 - 2(0.4772) = 0.0456$. 6.17 a. The mean remaining life for 25-year-old American males is normal with mean 50 and standard deviation 5. We want the proportion of this population that will live past 75. So we seek $P(X > 50)$ since a 75 year old has lived 50 years past 25. To cover to a standard normal, we note that if Z is standard normal it has the distribution of $(X - 50)/5$. So $P(X > 50) = P[(X - 50)/5 > 0] = P(Z > 0) = 0.50$. b. For the age of 85 we want $P(X > 60)$. $P(X > 60) = P((X - 50)/5 > (60 - 50)/5) = P(Z > 2) = 0.5 - P(0 < Z < 2) = 0.5 - 0.4772 = 0.0228$. c. We seek $P(X > 65) = P(Z > 15/5) = P(Z > 3) = 0.5 - P(0 < Z < 3) = 0.5 - 0.4987 = 0.0013$. d. We want $P(X < 40) = P(Z < (40 - 50)/5) = P(Z < -2) = P(Z > 2) = 0.5 - P(0 < Z < 2)$. $= 0.5 - 0.4772 = 0.0228$.

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